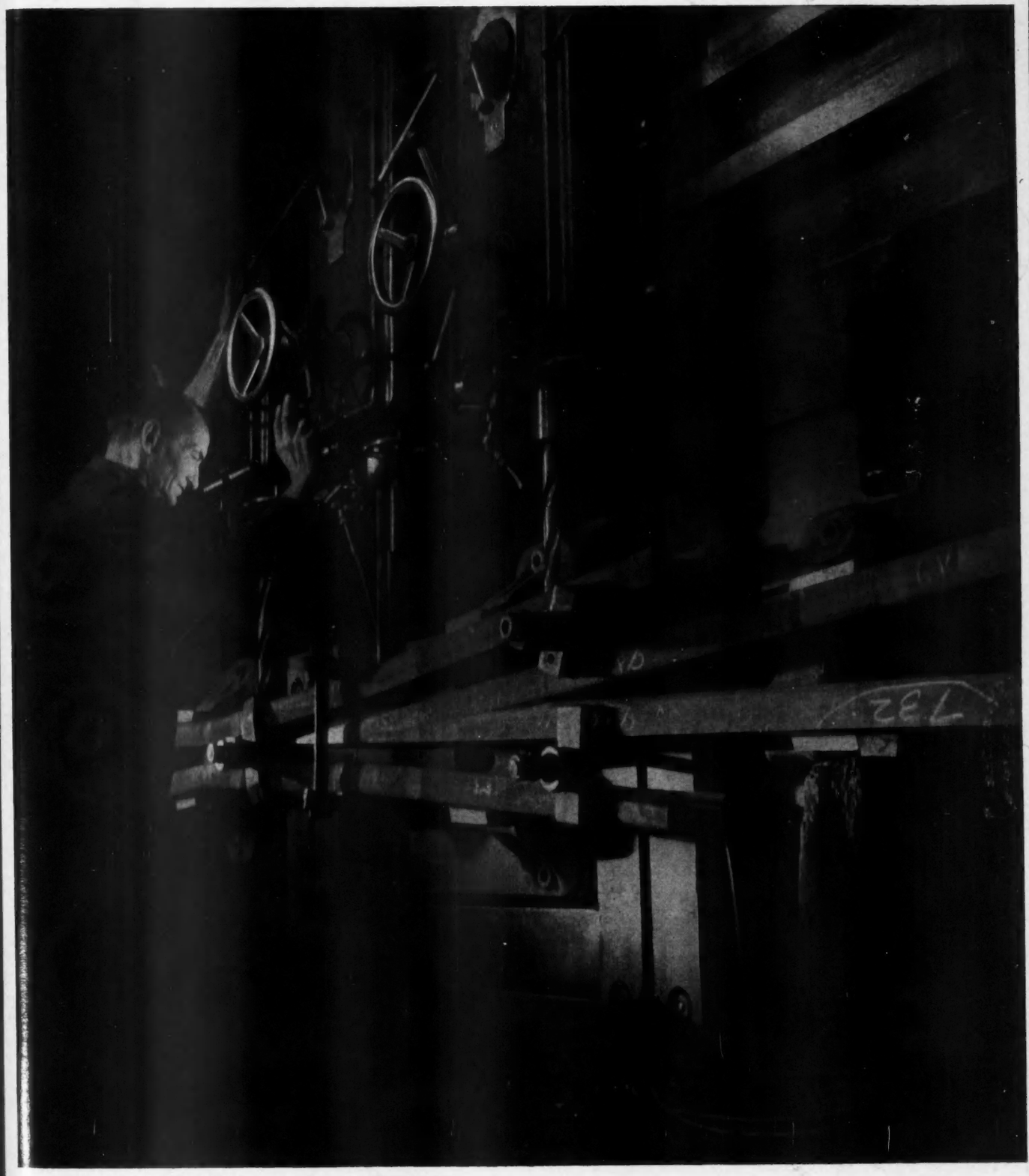
ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 TELEPHONE: TEMPLE BAR 3663

UNIVERSITY OF MICHIGAN
APR 30 1954

Vol. 177 No. 4603 LONDON, FRIDAY, APRIL 16, 1954 ENGINEERING Price 2s.



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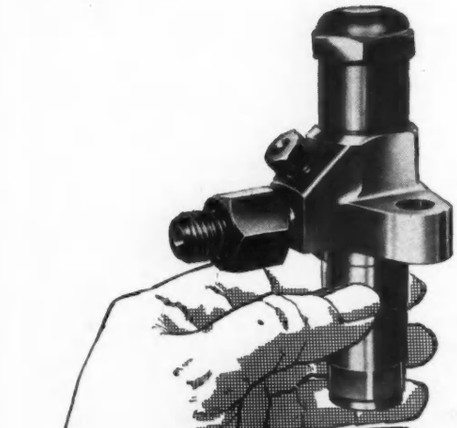

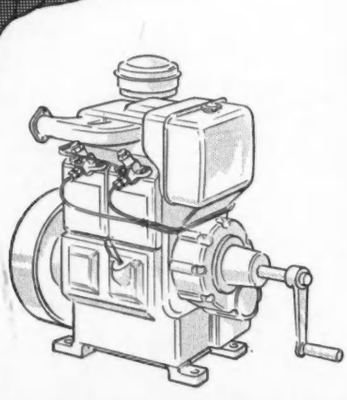

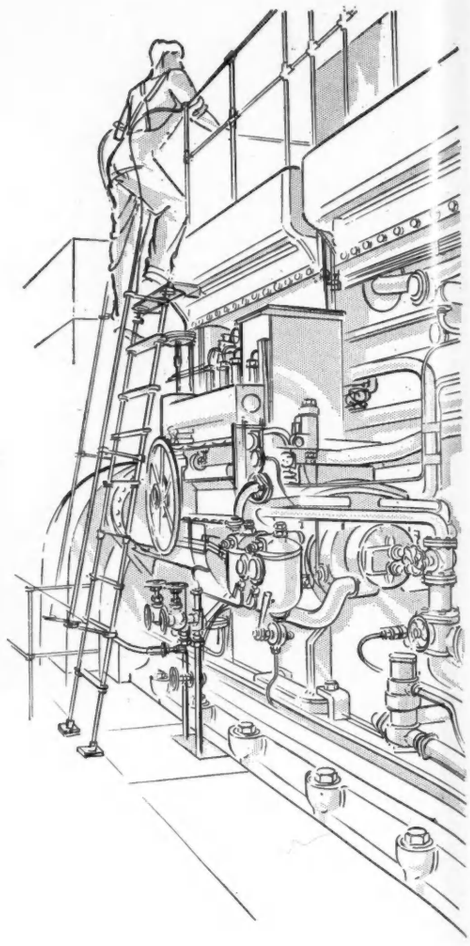

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ENGINEERING

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Published every Friday by Engineering Limited 35 & 36 *Bedford Street, Strand, London, W.C.*2
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

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Subscription Rates for 12 *months, inland and abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* [2*s.* 3*d.*]

ELECTRIC TRACTION

ELSEWHERE in this issue we give an abbreviation of two very long reports which are to be presented to the International Railway Congress Association at their 16th session in London next month. As is usual, these reports are based on *questionnaires* which were sent to members and, in this case, requested information regarding the basic characteristics of the electric traction systems now in use, as well as the reasons why one system had been preferred to another. The authors are Mr. S. B. Warder, Chief Officer (Electrical Engineering), the Railway Executive, British Railways, and Professor C. Guzzanti, of Rome. Both deal, in particular, with four aspects of the problem: power supply; overhead line and fixed track installations; motive power units; and working and maintenance costs. In performing their task they cover a great deal of ground and present much detailed statistical information, the usefulness of which to those concerned is made evident by even a cursory study.

On the other hand, the railway administration which is considering the conversion of their system to electric traction is given little or no guidance as to the best course to adopt; rather the contrary. For instance, the British Railway Executive state that they chose direct current owing to the reliability of the equipment and the unsuitability of alternating current for heavy suburban services. The Swedish State Railways consider that direct current is unsuitable for long distances and for the relatively light traffic on the majority of their lines. The South African Railways selected direct current for the very reason that the traffic was light and consider that it has been justified by the success of the mercury rectifier.

Most of the administrations seem, however, to be satisfied with their choice, although the Central Indian Railways would like to change to alternating current at 11 or 22 kV and 50 cycles, a desire which is a tribute to the success of what even the optimistic must still regard as an experiment. In other cases it is hinted that a change would be made were not economic reasons an obstacle. The majority of the replies are less categorical. Even so, it is clear that the implication that technically and economically one system may be preferable to another cannot be sustained.

This inherent fallacy—that a "best" system of electric traction exists for all railways—is skilfully exploded by Mr. Warder. Every electric railway, he points out, comprises both fixed installations and motive power units. In a particular case – say a long line carrying light traffic – the cost of overhead line for a 1,500-volt direct-current system would be double that for a 25-kV 50-cycle system. If the latter system were used there would also be a considerable saving in substations and feeders, although the motive power units would be rather more expensive. On the other hand, in the case of a short line carrying heavy traffic, the cost of the two systems would be equal. More generally, a system which is "best" for fixed installations and less good for motive power units offers more advantages when the traffic is light and the line runs through easy country. The reverse is true when the traffic is heavy and constructional difficulties grave, since under such conditions the system which is "best" for the motive power units is preferable. This being so, unless a system is developed which is equally attractive from both these aspects, it is clearly impossible, in Mr. Warder's view, that any one of those available can be technically and economically best for all countries or even for every part of a particular railway network.

Apart from traffic and topographical conditions, the choice may be made more difficult by electrification having taken place on one system, and a better system having subsequently become available. In such a case the new system would have to possess very great advantages to make it economical to adopt it. The fact that such action was taken when the single-phase lines of the London Brighton and South Coast Railway were replaced by direct current, and the similar action which was taken with certain three-phase lines in Italy, does not detract from the soundness of this argument. Choice may also be influenced by the desirability of interrunning, as pointed out both by Mr. Warder and Professor Guzzanti.

The information given in both reports shows that the predominating systems of electric traction now in use are those employing direct current at either 600, 1,500 or 3,000 volts, and low-frequency alternating current. An interesting newcomer, since this question was last considered by the Association 20 years ago, is the 50-cycle alternating-current system. This has already been employed in Hungary for some time, while the experiments which have been made with it in France and Germany have been satisfactory enough to lead to its adoption on the Valenciennes-Thionville line, as well as on the Bas-Congo-Katanga Railway. Its principal weakness resides in the characteristics of the alternating-current motor, to overcome which great efforts are being made. If these are successful a formidable competitor may arise.

Weekly Survey

OWEN FALLS

The Owen Falls hydro-electric scheme in Uganda, on which we are publishing two articles (the first being in this issue), is the first phase of a planned attempt to develop major industries in this British Protectorate. Uganda is entirely lacking in coal and oil; it has some valuable mineral resources but so far they have been worked only on a small scale. The purpose of the development plan is to widen the basis of the country's economy, which is at present almost entirely dependent on a peasant agriculture. The decision to go ahead with the hydro-electric scheme was an act of faith, since it was not until work was well advanced that the industrialists, who would eventually use the hydro-electric power, were reasonably confident that the scheme would be completed. Textile manufacture and the mining and smelting of copper ore will be two principal industries. The new dam at Owen Falls controls the source of the White Nile—the 26,000 square mile Lake Victoria. Part of the water passes through the turbines and part through sluice gates, which are regulated to suit irrigation requirements in Egypt. The scheme has been planned and executed since the war. Power will soon be available to meet all demands, and the long-term prospects are already so favourable that the construction of a second station may have to be considered in the not too distant future. When the Queen formally inaugurates the scheme at the end of this month she will set a seal on a great enterprise, which should provide the means for a rising standard of living for a growing native population.

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EFFECT OF INVESTMENT ALLOWANCES

The new system of investment allowances announced in the Budget last week is a step in the right direction of stimulating capital investment. In principle, of course, these allowances are a form of improvisation, just as were the initial allowances which they replace for certain classes of investment. They have been added to a complicated structure of company taxation which is already bedevilled by the confusion between historical and replacement cost. But the change is likely to have a stimulating effect on the decisions of company boards under certain circumstances when they come to the question of increasing their plant and equipment. The new arrangement offers allowances that in the end will amount to 120 per cent. of the value of the equipment, which involves a cash relief worth about 10 per cent. of the cost of the plant and 5 per cent. of that of the buildings, for the new allowances give 20 per cent. on new plant and equipment and 10 per cent. on buildings for approved categories of capital assets in addition to the usual depreciation allowances.

Among industries most likely to benefit from the change is shipbuilding, since the new allowances are likely to be of considerable assistance to shipping companies. Other industries making larger items of capital equipment may also gain additional orders, but companies making what might be termed medium-sized goods, such as the middle ranges of the machine tool industry, may be slower to benefit, while companies supplying industries which are less concerned at the moment with taxation relief on new equipment and more on sales and purchase-tax problems (a case in point is the textile machinery industry's prospects in the light of unchanged purchase tax on textile goods in the home market) are not likely to see any noticeable improvement from this source for some time.

A great deal depends on the state of thinking at board level. There will be cases in all industries where the prospect of a 20 per cent. immediate addition to depreciation allowances, coupled with a degree of cash relief, will bring quicker and more optimistic decisions, but generally speaking the larger the sums involved the more welcome and stimulating the change in allowances will appear.

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INTERNATIONAL TELECOMMUNICATIONS

Long-distance telecommunication is currently in the news. Cable and Wireless, Limited, was formed on April 8, 1929, as a result of the Empire Wireless and Cable Conference held in London a year earlier and the silver jubilee of this event is recorded in a booklet entitled "World Wide Communication." This shows that the services which this organisation now operates, directly or through associated concerns, include external cable or wireless systems in more than 20 countries in Europe, Asia, South America and the Caribbean and external cable or wireless networks in most of the Crown Colonies. It owns 150,000 miles of submarine cables, which it maintains by means of a fleet of eight ships, and operates 104 wireless telegraph circuits, 87 radio telephone circuits and 22 coast wireless stations, as well as air communication stations. It is further responsible for the technical facilities of four broadcasting services and for one complete broadcasting service. Each year about 490 million words are carried.

The operation of such a widespread system has, of course, only been rendered possible by the introduction of numerous technical improvements, among which mention may be made of the use of Telecothene, instead of gutta-percha, as an insulating material, and of the double-current cable code apparatus, which enables two separate channels of communication to be sent over a single radio path. Such developments have the sole objective of maintaining and increasing the speed of this British Commonwealth's communications life line and no doubt they will be followed with equal success by others.

In last week's issue we published a note on the submarine telephone cable system which it is proposed to lay across the Atlantic. These cables, the design of which is of great interest, will make 29 telephone circuits available between London and New York and thus between the telephone systems of these countries. A further six circuits will be available between London and Montreal, as well as a number of telegraph circuits to Canada. It will also be possible by the use of these cables to maintain better communications with Australia and New Zealand.

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SURVEY OF CANALS AND INLAND WATERWAYS

The British Transport Commission announce that in accordance with the statement recently made to Parliament by the Minister of Transport and Civil Aviation, a survey of canals and inland waterways is to be undertaken, of which the terms of reference will be as follows: "To survey the use at present being made of the Commission's inland waterways, and to report to the chairman of the Commission—(*a*) whether all possible steps are being taken to ensure that the maximum economic advantage is being derived from the canal system under the Commission's control, and (*b*) as to the steps to be taken in regard to such of the Commission's inland waterways as can no longer be put to economic commercial use." The chairman of the Commission (Sir Brian Robertson) appointed Lord Rusholme as the representative of the Commission and the Minister of Transport has now approved Sir Brian's appointment of Sir Rex Hodges and Mr. R. D. Brown as independent members forming a small Board of Survey under Lord Rusholme's chairmanship. Sir Rex Hodges was formerly general manager and secretary of the Mersey Docks and Harbour Board, and Mr. R. D. Brown (of R. D. Brown and Partners, chartered civil engineers, Manchester) is experienced in design, construction and operation of canals and other public works in this country and abroad. Mr. Brown practises in association with Sir William Halcrow and Partners and Emeritus Professor A. H. Gibson.

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REDUCING NOISE AT AIRPORTS

Several British firms are working on designs for mobile sound mufflers which could be built on to trucks and towed round an airport and attached to aircraft before their engines are run up, it is stated in a recent news-letter issued by the Society of British Aircraft Constructors. The designs are still in the project stage, but it is hoped to be able to construct a unit for test in the near future. Aircraft and engine manufacturers, as well as airport authorities, are interested in the projects.

In a typical design a single muffler is intended to serve both the engines in one wing, being connected to the jet pipe by a funnel-shaped adaptor.

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SIGNS AND SYMBOLS

The present lack of uniformity in the use of symbols, signs and abbreviations in technical and scientific publications is a source of unnecessary irritation to readers as well as a time-consuming detail in the work of editorial staffs. An improvement may result from the publication by the British Standards Institution of B.S.1991, Part I—1954, "Letter Symbols, Signs and Abbreviations," which has been prepared with the advice of the principal learned and professional societies, research associations and other bodies concerned, as well as of editors and representatives of scientific and technical publications. One of the few major departures from current practice is the use of S to denote entropy. It is, however, a departure only for mechanical engineers in this country (who normally use ϕ), since S is commonly used by physicists and chemists throughout the world, and by most engineers in other countries. Certain well-defined principles govern the standards proposed, but in addition it is clear that the committees concerned have aimed to omit unnecessary details, to achieve clarity of expression, and to adopt a standard which should facilitate international, as well as national, understanding of technical data. The first part of the Standard covers the fundamental quantities, etc., of common interest to physicists, chemists and engineers; thus there are sections on mathematical operations and constants, physical quantities (mensuration, kinematics, mechanics, electricity and magnetism, light, thermodynamics, chemical composition and reaction, chemical thermodynamics, and electro-chemistry) and abbreviations of names of units. Later parts will serve specialised fields. As soon as appropriate arrangements have been made, B.S.1991 will be adopted as standard practice in ENGINEERING.

NEW HEAVY-GUN TANK

The new heavy-gun tank for the Army, the Conqueror, would seem to combine all those features of design, for a tank of its class, which were found to be desirable during the war. Much of the armour is sloping, to deflect enemy fire; the gun is large – its calibre is not stated but it is said to be more powerful than the 20-pdr. of the Centurion tank; the silhouette is low; and the tracks have a large bearing area to ensure good cross-country mobility.

Few details of the design have been released but certain features are apparent from the illustrations below. The turret is exceptionally large from front to back for a tank with a crew of four, presumably because of a long recoil of the gun. It is evidently of cast-steel, and it has a hinged door on the side. The heavy armour at the point where the gun barrel passes through the turret is noteworthy, and the oblique slope of the nose armour is clearly an essential feature of a tank which is evidently intended to be employed as a "tank-killer."

The tracks resemble those of the war-time Churchill tank, both in the construction of the links and in the suspension system – a series of small rollers rather than a few large wheels of the type used on cruiser tanks – though the suspension is of a new and improved design developed to take the increased weight.

The Conqueror's weight is not given, but it is greater than that of the Centurion. The drive is from a high-powered Meteor engine. The development of the tank by the Ministry of Supply "in close co-operation with British industry" is said to have involved many problems in suspension, power and transmission and in the gun-control system.

The War Office and the Ministry of Supply have announced that the Conqueror is now in "limited production" and that initial issues for troop trials by the British Army in Germany will begin in the next two or three months. Bridging and recovery equipment are being provided to suit the increased weight. A heavy girder bridge, similar to the Bailey bridge and able to carry the heaviest loads at present envisaged in the Service, is being produced and will soon be issued to units. A new recovery vehicle is also being built.

The armour forming the nose is well sloped to deflect enemy fire.

The Conqueror tank, now in production for the Army, is larger, heavier and more powerful than the successful Centurion. It has an exceptionally large turret.

* * *

Letters to the Editor

HIGH-SPEED CALCULATING

Use of Small Electronic Computers

SIR, Your references to the rapid progress made with the development of electronic computers on page 395 of your issue of March 26, emphasise that high costs still restrict the field of application of "all but the simplest" to research institutions. With this statement there can be no quarrel; but it is the so-called "simplest" of these computers, to which no further reference is made, that are of present interest to industry and commerce, and in this sphere Britain has made strides greater than those achieved elsewhere.

For instance, at the beginning of 1952, the British Tabulating Machine Company, Limited, introduced at the Business Efficiency Exhibition in Birmingham the first punched-card electronic multiplier to function in direct sterling. This installation comprised two main units: a normal punched-card standard gang punch, linked with the new electronic multiplier. The gang punch caters for the input and output of the Hollerith cards, from which the multiplier senses the multiplicand and multiplier and transmits them by electrical impulses to the strictly functional mechanism of the machine. The calculation is then done electronically at a speed measurable in milliseconds and the product transmitted back to the punch unit on the output side of the gang punch, where it is punched into a selected field on the same cards. For practical purposes the speed of multiplication must be considered that of the gang punch, but even that is 6,000 cards an hour, quite as fast as the bigger machines could be commercially operated if they were economic in such a field.

Again, at the end of 1952, Powers-Samas Accounting Machines, Limited, introduced a virtually single-unit electronic multiplier which was only 5 ft. 6 in. high and about the same measurement across. This machine, which is designed to be an integral part of a punched-card installation, like the Hollerith, is far easier to operate than the great experimental models and is capable of simple calculations without undue waste of time in preparing the coded information with which to feed it. A sum like the multiplication of 14*s.* 7·29*d.* by 76·37 takes the machine about half a second including checking by a different method, and already a number of these have gone into practical routine use in this country and the first to be shipped to the United States left London early in March.

At last year's Olympia Exhibition, the British Tabulating Machine Company, Limited, came out with an electronic computer which, on being given a contract bridge hand, made an opening bid. This clearly is not a machine for small undertakings, but nevertheless, it certainly offers scope for economy of labour in the preparation and compilation of accounting as well as statistical, engineering and scientific data. In short, it is hardly too much to say that anyone with an economic use for a complete punched-card installation would be justified in investigating its possibilities. For the average computing work undertaken by most industries, one high-speed electronic machine with an operating staff of three to four is capable of producing a vast amount of information quite beyond the scope of normal punched-card equipment, and at the same time it will do more efficiently and speedily the routines at present produced by punched-card installations which might require as many as ten or twelve people. Initial outlay, it is true, would be higher; but as against that, the running costs and economies achieved make other comparative costs negligible and, if anything, greater accuracy is ensurable.

Yours faithfully,
S. GORDON SLOAN,
President.

Office Appliance and Business Equipment Trades Association, 94-98, Petty France, London, S.W.1.
April 8, 1954.

* * *

SHEFFIELD TRADES HISTORICAL SOCIETY

At the 21st annual general meeting of the Sheffield Trades Historical Society, held in the Mining Department's lecture theatre of Sheffield University on April 5, Mr. E. Walker, A.M.I.Mech.E., who has been President of the Society for the past two years, inducted as his successor Mr. R. W. Allott. The election was announced, as vice-presidents, of Mr. J. B. Himsworth, Mr. C. H. Lea, Colonel W. Middleton, Dr. R. A. Mott and Mr. W. Ragg; and as members of the Council, of Miss D. Greene, Miss M. Walton, Mr. J. F. Bridge, Mr. H. Cantrell, Mr. W. A. Culley, Mr. J. T. Higgins and Mr. W. B. Oxley. Mr. W. H. Bailey continues as honorary secretary and Mr. D. J. Bradbury as honorary treasurer.

The meeting was followed by a lecture on the history of iron-making in the North of England, by Dr. R. A. Mott, in the course of which he emphasised that the "Sheffield thwitel" that Chaucer's miller, in the Reves tale, "Baar . . . in his hose" was much more likely to have been a product of Sheffield in Yorkshire than, as had been suggested, of the lesser-known Sheffield in Sussex. There was ample evidence, he maintained, that iron-making had become a considerable trade in the north of England by the late Fourteenth Century, when Chaucer wrote the *Canterbury Tales*.

* * *

BIRMINGHAM ENGINEERING CENTRE

The new Birmingham Exchange and Engineering Centre, which will form a permanent display for medium and light engineering products, is to open in June. About 200 firms have taken space at the Centre, which is in Stephenson's-place.

MACHINES FOR LAND DRAINAGE

Attachments for Small Tractors

A demonstration of machinery suitable for land-drainage operations was arranged by the Ministry of Agriculture and Fisheries at Charndon, Buckinghamshire, on March 30 and 31.

The Ministry considers that an increased production of food is dependent on good drainage which, owing to the shortage of labour, is almost entirely again dependent on the right type of machinery being available. The object of the demonstration, therefore, was to encourage the proper draining of agricultural land by giving farmers, contractors and county officials an opportunity to decide which machines were most likely to satisfy their individual requirements.

COMPLETELY MECHANISED

The demonstration was held on heavy-clay land, with a thin top soil; the going was, therefore, difficult, and in some parts of the demonstration area quagmire conditions prevailed. The demonstration included a drainage scheme which was being carried out by a completely mechanised unit. It consisted of a rotary-type machine for digging the trenches and fitted with a device for grading and laying the tiles, or pipes; a back-filler mounted on a tractor; and, also mounted on a tractor, a scoop whose movements were hydraulically controlled; a tipping trailer for handling material; and, lastly, a second trailer for transporting the trenching machine.

The demonstration also included an exhibition of the principles of draining the subsoil of agricultural land. A number of plaster casts were shown taken from mole-drains, which had been in existence for up to six years; these casts clearly indicated the useful life of this type of sub-soil drain and how it slowly collapses and becomes useless after a few years.

Machines for digging trenches were shown by seven makers, the majority being designed as attachments to farm-type tractors. Of these machines, the "Atos," made by John Allen and Sons (Oxford), Limited, Cowley, Oxford, and the "Dinkum Digger," made by Whitlock Brothers, Limited, Great Yeldham, Essex, are provided with hydraulic controls. In the category of machines for the maintenance of ditches, the products of ten makers were demonstrated and many of these machines also took the form of attachments to farm-type tractors.

The Priestman Wolf excavator, Mark III B, made by Priestman Brothers, Limited, Holderness Engineering Works, Hull, was demonstrated with the makers' patented side-dragline equipment using a bucket with tapering sides. This machine, which was shown digging a ditch alongside a hedge, has a 4-cylinder Diesel engine developing 33 brake horse-power. As a side-dragline it weighs 10·75 tons, which results in a loading on the tracks of 7·25 lb. per square inch.

DITCHER ON PONTOONS

An unusual type of machine which could not be demonstrated was the "Ritcher" ditch maintenance machine made by Henry Hirst (Sheffield), Limited, Bourne, Lincolnshire. This machine is mounted on pontoons and has a cutter working on the principle of an Archimedian screw; the cutter is partially enclosed and mechanically driven and arranged for lateral and vertical movement, the spoil and water being spread to one side by a separate expeller.

THE RAND WATER BOARD OF SOUTH AFRICA

SUPPLIES IN A LAND OF LOW RAINFALL

The Rand Water Board have now passed their fiftieth anniversary and in a publication entitled "Rand Water Board, 1903-1953," the Board trace their development from their inception following those pioneering days of the last century when, in 1885, gold was first discovered in the conglomerates of the Witwatersrand and, in 1888, the first bore-hole for water was sunk in Johannesburg.

South Africa, so richly endowed with many natural resources, is ill-favoured in regard to rainfall and water is therefore scarce, particularly in the high lands of the Witwatersrand. In 1889, it is stated, the charge for water in Johannesburg was 1*s.* 6*d.* per 100 gallons.

By 1895, the year of the great drought, the population of Johannesburg had reached 102,000, of whom half were Europeans, and in that year, as a result of persistent complaints, a Commission of Enquiry was set up to examine "in what way Johannesburg can be provided with good and pure drinking water." The outbreak of the South African war in 1899 stifled any resulting action but, in 1901, a second Commission recommended the establishment of a public body to be called the Rand Water Board "charged with the duty of supplying water to the municipalities and the mines of the Witwatersrand from Springs to Randfontein," The Rand Water Board was thus brought into being, and held its first meeting in mid-May, 1903.

EVER-INCREASING DEMAND

The demand for water has been linked with the fortunes of the gold-mining industry and has been equally unpredictable. By 1911, the demand had reached 9 million gallons a day, approaching the limit of the bore-holes. In 1914, however, authority was obtained to proceed with a scheme to take up to 20 million gallons a day from the Vaal river at Vereeniging, 35 miles to the south of Johannesburg, and to pump the water to that city, which stands at a 1,000 ft. higher level. The execution of this scheme, which required the building of a barrage 1,400 ft. in length, filter-plants and pumping stations, was delayed by the outbreak of the 1914 war. The various works were not completed, therefore, until 1923, by when the demand had risen to 11½ million gallons a day.

By 1933 the demand approached 20 million gallons a day and it became necessary to increase both resources and supplies. The Board, therefore, contributed towards the building of a dam on the Vaal river, primarily intended to impound water for irrigation purposes, and it acquired the right to abstract up to 215 million gallons a day. This dam provides a maximum depth of water, above the level of the tail-water, of 100 ft. and impounds 234,000 million gallons; it is situated approximately 50 miles upstream of the barrage at Vereeniging, or about 10 miles above the upper limit of the pond created by the barrage. Water stored behind the dam is, therefore, passed down to be abstracted by the Board's intake station at the barrage.

Having assured a source of adequate supply, the problem during the past 20 years has been to keep pace with demand and to provide, in spite of the interruption caused by the 1939 war, the necessary extensions to filter plants, pumping stations and pipe-lines to meet an always unpredictable future requirement.

The forty-eighth annual report of the Board covers the period ended with March 31, 1953 and it states the average daily consumption had by then reached the astonishing figure of 103 million gallons, approximately one third of the consumption of the London area.

PRESENT-DAY TREATMENT

The original bore-holes have been mostly abandoned during recent years and the principal source of supply has now become the Vaal-river. After abstraction from the river the water, which contains a quantity of suspended matter, is passed through primary and secondary mixing and sedimentation tanks. The designed capacity of this plant is 104 million gallons a day and the time of retention at this capacity is 14 hours. After clarification the water is passed through 102 gravity filters at the average rate of 60 gallons per square ft. per hour and is then collected in underground covered reservoirs and chlorinated before being pumped into the mains.

Pumping is in two stages; the first stage is from Vereeniging to Zwartkopjes, a distance of 27 miles, the installation consisting of centrifugal pumps, with a lift of 530 ft., driven by steam-turbines; the second stage from Zwartkopjes to Johannesburg involves a pumping-head of 1,150 ft., and again the installation consists of centrifugal pumps driven by steam-turbines.

From Johannesburg, the water is distributed to the neighbouring townships, to the various mines and northwards to Pretoria which is approximately at the same level as Vereeniging and about 35 miles from Johannesburg.

The areas covered are vast; the limits of supply extend to 4,300 sq. miles, of which 735 sq. miles falls within the areas of constituent local authorities. At the end of March, 1953, the total length of mains, between 6 in. and 4 ft. 6 in. in diameter, is stated to have reached a total of 484 miles, and the horse-power of prime-movers to have totalled to 113,107.

UTILISATION AND REVENUE

In the statistical section of the annual report there is information regarding storage, evaporation, bacteriological examinations, dosage of chemicals and filter performances, together with the following figures which relate to the growth of the total annual consumptions of water by specified consumers or classes of consumers. The table below, which has been abstracted from the information given, shows the remarkable development which has taken place during the period of 47 years ending in 1953.

Total Annual Consumption of Water in Millions of Gallons by Various Classes of Consumers

Consumer	Year 1905-06	Year 1952-53
Johannesburg Municipality ..	716	12,050
Witwatersrand gold mines ..	96	12,818
South African Railways ..	Negligible	1,597
Other municipalities and authorities	39	11,925
Total ..	851	38,390

All water supplied is metered and the losses are stated to have been 2·497 per cent. of the total potable water produced. The revenues for the year ended March 31, 1953, on the basis of a charge of 7½*d.* per 1,000 gallons of water sold, amounted to £1,199,700.

OBITUARY

MR. R. W. NEWMAN

Irrigation in South Africa

We have learned with regret of the death of Mr. R. W. Newman, one of the oldest members of the Institution of Civil Engineers, and a former President of the South African Society of Civil Engineers. Mr. Newman, who was 85, had been living in retirement for some years in Southport, where he died on March 22.

Reginald William Newman, who was born on April 16, 1868, was the son of a doctor and received his general education at Epsom College (then known as the Medical College) and at Marlborough. After a year at Owen's College, Manchester, he served an apprenticeship to general engineering with Henry Watson and Son, Newcastle-on-Tyne, and then spent three years in the office of Mr. T. H. Burroughs, F.S.I., of Beckenham, Kent, where he was engaged mainly on the construction of roads and sewers. In 1892, he was engaged as assistant engineer with Messrs. Lucas and Aird, public works contractors, on the widening of the London, Chatham and Dover Railway between Shortlands and Bickley, remaining with them and their successors, John Aird and Sons, for 11 years.

In 1903, Newman went to South Africa as a member of the staff of the Cape Government Public Works Department, his first duties being those of resident engineer on the Thebus irrigation works, under W. B. Gordon, M.I.C.E., the then Director of Irrigation in Cape Province. This was followed by a similar appointment on the removal of the Lady Grey Bridge and the erection of the Huguenot Bridge at Paarl. From 1905 to 1908 he was in charge of the Department's Eastern District, and for the following three years of the Midland District. Eventually, under the Union of South Africa Irrigation Department, of which Mr. F. E. Kanthack, M.I.C.E., was then Director, he had charge of an area of about 25,000 square miles, extending to the border of Natal. In 1918 he undertook what was probably the most important undertaking in his career, namely, the construction of the Lake Mentz reservoir of the Sundays River Irrigation Board, Cape Province, on which he was occupied for five years. On its completion he left the Government service and set up in practice as a consulting engineer at Port Elizabeth. He continued to practise there until 1930, when he returned to England.

Mr. Newman was elected to the Institution of Civil Engineers in 1893 and to the Institution of Mechanical Engineers in 1897. He was also a member of the South African Society of Civil Engineers, of which he was President in 1921, a Fellow of the Royal Sanitary Institute, and one of the oldest members of the Junior Institution of Engineers, to which he had belonged for 63 years. He was made an honorary member of this Institution in 1938.

* * *

MR. C. A. CLENCH

Construction of Power Stations

We also regret to record the sudden death of Mr. C. A. Clench on Saturday, April 3. He was 54 years of age.

Clarence Arthur Clench served his apprenticeship with the British Thomson-Houston Company and, after serving with the Royal Air Force during the first World War, returned to that concern in a junior position. In 1927, he joined the staff of the London Power Company, where he occupied posts as draughtsman, assistant constructional engineer and senior assistant constructional engineer. On the formation of the British Electricity Authority he was appointed Generation Engineer (Construction) and was promoted to Chief Generation Engineer (Construction) in 1951.

Mr. Clench was elected an associate member of the Institution of Mechanical Engineers in 1935 and became a member in 1949.

* * *

PERSONAL

MR. N. C. ROBERTSON, C.M.G., M.B.E., deputy managing director of E. K. Cole Ltd., Ekco Works, Southend-on-Sea, Essex, has been elected a director of Ekco Electronics Ltd., a wholly-owned subsidiary company of E. K. Cole Ltd. MR. ROBERT WRATHALL has joined E. K. Cole Ltd. as radio sales manager.

The temporary appointment of DR. J. PEARSON, M.Sc., F.R.I.C., as head of the steelmaking division of the British Iron and Steel Research Association, in addition to his existing appointment as head of the chemistry department, announced in January of this year, has now been made permanent.

PROFESSOR W. WARDLAW, C.B.E., D.Sc., F.R.I.C., has been elected President of the Chemical Society, Burlington House, London, W.1.

MR. W. P. HECKELS, shipyard manager to John Readhead & Sons, Ltd., South Shields, has been elected a director of the firm.

WING-COMDR. W. F. BLACKADDER, a director of Walter Runciman & Co. Ltd., Newcastle-upon-Tyne, has been elected chairman of the North of England Shipowners' Association in succession to MR. G. R. FOREMAN, of Tynemouth.

MR. S. E. HOLMES, A.R.I.C., A.F.Inst.Pet., has been appointed manager and MR. H. M. WHITE, B.A.(Cantab.), assistant manager of the department for technical information of C. C. Wakefield & Co. Ltd.

MR. W. J. STAY, chief engineer, the Electric Construction Co. Ltd., Bushbury Engineering Works, Wolverhampton, retired on March 31 after 47 years of service with the company.

MR. O. THOTT, M.I.Mech.E., who has filled the position of managing director of Boving & Co. Ltd., 56 Kingsway, London, W.C.2, since 1931, has been appointed vice-chairman of the company from April 1. From that date he will be succeeded as managing director by MR. D. A. AKINS, B.E., A.M.I.C.E., who has been with the firm since 1934 and a director since the beginning of last year.

MR. C. C. LAST, a director and joint general manager of Bakelite Ltd., 18 Grosvenor-gardens, London, S.W.1, has been elected vice-chairman of the British Plastics Federation.

MR. J. A. WYKES has been appointed managing director of Hoover Ltd., Hoover House, 211-213 Regent-street, London, W.1, in succession to SIR CHARLES COLSTON, C.B.E., M.C., D.C.M. MR. H. W. HOOVER, JNR., has been elected a director in place of MR. H. W. HOOVER, who has not sought re-election, and MR. O. M. MANSAGER has been appointed to the board.

MR. E. W. BENNETT has been promoted from chief production engineer to production manager of Hoover (Electric Motors) Ltd., Cambuslang, Lanarkshire.

MR. F. R. L. BARNWELL, O.B.E., A.M.I.C.E., has been appointed district engineer, Newport, Western Region, British Railways.

MR. E. H. BAKER, assistant divisional motive-power superintendent, Derby, London Midland Region, British Railways, has been made divisional motive-power superintendent, Crewe. MR. R. THOMPSON, district motive-power superintendent, Edinburgh, Scottish Region, has been made divisional motive-power superintendent, London Midland Region, Manchester.

MR. H. L. WICKES, A.M.I.E.E., has been appointed sales manager to B.K.B. Electric Motors Ltd., St. George's Works, Icknield-street, Birmingham, 18.

MR. H. W. WIDDOWSON, who has represented Keith Blackman Ltd., Mill Mead-road, Tottenham, London, N.17, in the South Wales area since 1914, retired on March 31. The area is now covered from the firm's Bristol office by MR. J. G. EMINTON, at 13 West Dene, Westbury-on-Trym, Bristol, Gloucestershire.

MR. F. N. YATES, 36A Brownsville-road, Heaton Moor, Stockport, Cheshire, has been appointed North-Western representative of Sunvic Controls Ltd., 10 Essex-street, Strand, London, W.C.2.

BUSINESS CHANGES

WILD-BARFIELD (SOUTH AFRICA) (PTY.) LTD. have now moved to larger premises at Elecfurn Works, Union-lane, Pinetown, Natal.

ASHMORE, BENSON, PEASE & CO. LTD., Parkfield Works, Stockton-on-Tees, proprietors of the POWER-GAS CORPORATION LTD., have concluded an agreement with GENERAL AMERICAN TRANSPORTATION CORPORATION, Chicago, U.S.A., to manufacture the patented Wiggins Hidek and Lodek floating roof structures for the petroleum and petrochemical industries.

As from April 1, FRANK PEARN & CO. LTD., manufacturers of reciprocating-type pumps, have been merged with HOLDEN & BROOKE LTD., now the sole manufacturers and suppliers of the pumps. All inquiries and business are being dealt with at the latter firm's head office, Sirius Works, Manchester, 12, and Messrs. Pearn's works constitute a production unit only.

* * *

CONTRACTS

Television Station Equipment. The British Broadcasting Corporation have placed contracts for the provision and erection of the masts for the transmitting aerials at the permanent medium-power television stations at Rowridge (Isle of Wight), Pontop Pike (near Newcastle-upon-Tyne) and North Hessary Tor (South Devon) with BRITISH INSULATED CALLENDER'S CONSTRUCTION CO. LTD., 21 Bloomsbury-street, London, W.C.1. Similar contracts for the provision and erection of masts for the station at Divis (Northern Ireland) and Core Hill (near Aberdeen) have been placed with J. L. EVE CONSTRUCTION CO. LTD., 17 Hillside, London, S.W.19. All the masts will be generally similar in construction and, with the exception of that at North Hessary Tor, which will be 750 ft. high, they will have a height of 500 ft. Two further three-stack super-turnstile aerials similar to that erected by MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, at Pontop Pike have been ordered by the B.B.C. from that company. It is understood that these have been allocated to Core Hill and Divis. Two-kW sound transmitters and 5-kW vision transmitters for North Hessary Tor, Rowridge, Core Hill, Pontop Pike and Divis are being manufactured by Marconi's Wireless Telegraph Co., at their Chelmsford works.

Passenger and Goods Lifts. THE EXPRESS LIFT CO. LTD., Abbey Works, Northampton, are to supply and install four gearless passenger lists and one two-speed passenger and goods lifts in a new building now being erected for the United India Fire and General Insurance Co. Ltd., at Madras. The gearless lifts will travel at a speed of 500 ft. per minute and will serve 14 floors. The passenger and goods lifts will serve 15 floors. Motor generators for the contract will be made by the parent company, the GENERAL ELECTRIC CO. LTD., at Witton Works, Birmingham.

Air Liners. VICKERS-ARMSTRONGS LTD., Vickers House, Broadway, London, S.W.1, announce that their AIRCRAFT DIVISION has received an order for three Viscount air liners from Misrair, S.A.E., Egypt. The first will be delivered in July next year and the other two almost immediately after.

Passenger Ships. Three new ships have been ordered by British Railways, London Midland Region, for the Heysham-Belfast route. They are to cost over £4 million. Each ship will carry 1,800 passengers, an increase of 300 over the present vessels, and be fitted with stabilisers to prevent rolling. The new vessels will be driven by turbine machinery and oil fired, the builders being WILLIAM DENNY AND BROTHERS LTD., and HARLAND AND WOLFF LTD. They will replace the three "Dukes" which have been on the route for over 25 years.

Hydro-Electric Plant. The North of Scotland Hydro-Electric Board, 16 Rothesay-terrace, Edinburgh, 3, have placed contracts for the St. Fillans section of the Breadalbane hydro-electric scheme, Perthshire. THE MITCHELL CONSTRUCTION CO. have been given the task of building the power stations at St. Fillans and at Dalchonzie, near Comrie, constructing aqueducts and driving over 10 miles of large water tunnels. The St. Fillans power station will be built underground; it will have a 22,000-kV machine. The alternators will be built by the HARLAND ENGINEERING CO. LTD., Alloa, and a generator by BRUCE PEEBLES & CO. LTD., Edinburgh. The capacity of the Dalchonzie station, to be built on the River Earn, will be 4,000 kW. TAYLOR WOODROW CONSTRUCTION LIMITED, are to construct the Lednock dam. This will be of the buttress type, about 930 ft. long and 100 ft. high, and its construction will involve the placing of over 100,000 cub. yds. of concrete.

THE INSTITUTION OF NAVAL ARCHITECTS

SPRING MEETING IN LONDON

The 1954 Spring Meeting of the Institution of Naval Architects was held in London, on Wednesday, April 7, and the two following days, the venue, as in several recent years, being the Wellington, headquarters ship of the Honourable Company of Master Mariners, moored in the Thames at Temple Steps. The proceedings opened with the annual general meeting, at which the chair was taken by the President, Viscount Runciman of Doxford, O.B.E., A.F.C., D.C.L. The annual report of the Council was presented by the secretary, Captain (S) A. D. Duckworth, R.N. (retd.).

ANNUAL REPORT OF COUNCIL

The report recorded that, at the Autumn Meeting in Holland in 1953, H.R.H. the Prince of the Netherlands honoured the Institution by accepting Honorary Membership. It was announced also that the Council had elected Instructor Rear-Admiral Sir Arthur E. Hall, K.B.E., C.B., an Honorary Vice-President in recognition of his services over a number of years as treasurer of the Institution.

The membership at the end of 1953, was 3,659, comprising eight honorary members, 1,245 members, 1,363 associate-members, 734 associates and 309 students. The deaths recorded during the year numbered 49 and included General Giuseppe Rota, Mr. H. Clark, Mr. J. B. Wilkie, Engineer-Captain E. F. Baker, R.N. (ret.) and Mr. J. W. Pile, all of whom had 50 years' membership or more.

The revised By-Laws and Regulations which were adopted at a special general meeting held on May 13, 1953, gave the Council power, *inter alia*, to form local branches of the Institution in areas where this might seem desirable. A joint Southern Branch was formed with the Institute of Marine Engineers somewhat earlier in the year, the inaugural meeting being held at Southampton on March 30, and steps have been taken to form a Branch in Australia – the first under the new By-Laws.

A gift of £10,000 to the Institution from Lord Weir of Eastwood has been allocated to the building of a new lecture hall adjoining the Institution's offices at 10, Upper Belgrave-street, S.W.1, which is to be known as the Weir Lecture Hall. It will hold about 180 persons and is expected to be ready early in 1955.

The Council have accepted a proposal by the Shipbuilding Conference that the Institution should establish an "Amos Ayre Lecture," to be delivered at intervals of three years, to commemorate the late Sir Amos Ayre. The Shipbuilding Conference have offered an honorarium of 50 guineas and an "Amos Ayre Medal," to be awarded to the chosen lecturer. It was hoped to arrange for the first to be delivered in 1955.

Two Institution Premiums were awarded for papers presented in 1953, the recipients being Mr. J. L. Bartlett, C.B.E., R.C.N.C., for his paper, "The Motions of an Aircraft Carrier at Sea in Relation to the Operation of Naval Aircraft," and Mr. R. T. Shiells, B.Sc., for his paper, "A Skin Friction Determination, using Wall-sided Models of Great Draught."

TONNAGE MEASUREMENT LAW

The report states that the original proposals of the Tonnage Measurement Laws Committee, regarding the allowance to be made for machinery spaces in computing register tonnage, were not accepted by the Ministry of Transport and Civil Aviation; but a modified amendment to the existing law was agreed upon by the Ministry, and interested marine authorities. After reference to other Governments, dock and harbour authorities and the trade unions concerned, an Amending Bill was drafted. It passed through both Houses of Parliament without opposition and received the Royal Assent on March 9, 1954. It provides that, for a 13 per cent. propelling-power space, the deduction from the gross tonnage shall be 32 per cent., and that this shall be reduced proportionately for space which is smaller than 13 per cent.

ELECTION OF OFFICERS, ETC.

The following were re-elected under the provisions of Regulation xvi(*b*) ; as treasurer, Instructor Rear-Admiral Sir Arthur E. Hall, K.B.E., C.B. ; as vice-presidents, Dr. James Montgomerie, C.B.E., Sir Frederick E. Rebbeck, K.B.E., Sir Stephen J. Pigott, D.Sc., Mr. E. Leslie Champness, M.B.E., M.Sc., Sir Charles S. Lillicrap, K.C.B., D.Sc., Sir George W. Barr, C.B.E., Mr. Lloyd Woollard, M.A., Sir James M. McNeill, K.C.V.O., F.R.S., Sir Summers Hunter, Professor A. M. Robb, D.Sc., Sir Wilfrid Ayre, Sir Victor G. Shepheard, K.C.B., Sir A. Murray Stephen, M.C., B.A., Dr. R. W. L. Gawn, O.B.E., Mr. Norman M. Hunter, and Sir Robin Rowell, C.B.E., A.F.C.

The following were elected as Members of Council: Mr. F. C. Cocks, B.Sc., Dr. J. F. C. Conn, Mr. Charles Connell, M.A., Mr. W. J. Ferguson, M.Eng., Mr. G. H. Houlden, M.B.E., Mr. W. G. John, Mr. James Lenaghan, Dr. S. Livingston Smith, C.B.E., and Mr. R. K. Wood, B.Sc.; and, as Associate Members of Council, of Sir Colin S. Anderson, Captain W. H. Coombs, C.B.E., R.N.R., and Captain G. C. Saul.

PRESIDENTIAL ADDRESS

The year 1953, the President observed, had been a very full and satisfactory one for the Institution. First, there was the revision of the By-Laws, with particular reference to the new By-Law 24, which empowered the Council to form Branches. The Southern Joint Branch of the Institution with the Institute of Marine Engineers was flourishing and he hoped that it might lead to the formation of others on similar lines; but the most spectacular event in that connection was the formation of the Australian Branch, which was due to the initiative of Mr. Cecil Boden (Member) in Australia. He had had it in mind to form a counterpart to the Institution in Australia, but when he discussed the possibility with Dr. S. F. Dorey, who was visiting the Dominion at the time, it was agreed to seek to form a Branch. A constitution had been drawn up and agreed by the Council, and the Branch had been established. He looked forward to a great future for it. Referring to the establishment of the Amos Ayre Lecture, he stated that Sir Robin Rowell had undertaken to deliver the first.

On the subject of tonnage measurement, the President said that all concerned owed a great debt to the persistence of Sir Stanley Goodall. They had achieved at last a modest, but exceedingly useful, step in the right direction, and it was appropriate that due acknowledgment should be made to him in bringing it about.

In 1953 they had held a very successful Autumn Meeting in Holland, and he was pleased to welcome Professor Ir. H. E. Jaeger, who had done so much to ensure the success of that meeting, and a number of his countrymen. The Autumn Meeting in 1954 would be held at home – at Torquay – and they were fortunate in being able to combine with it the ceremony of unveiling the memorial to William Froude.

Referring to the papers which were to be presented to the Spring Meeting, Lord Runciman drew attention particularly to two of them, which touched on subjects of very great public interest. One was by Lieutenant-Commander J. N. Bathurst, O.B.E., D.S.C., R.N., on underwater television which had promise of the greatest value and usefulness; and the other was Sir Victor Shepheard's paper on the Royal Yacht, H.M.S. Britannia.

The President then invited Sir Victor Shepheard to present his paper.

THE ROYAL YACHT "BRITANNIA"

An outline design for a new royal yacht, Sir Victor said, had been prepared in 1938 and circulated to some of the principal shipbuilders, but, with the advent of war in 1939, the matter was dropped. It was revived in 1951, with the idea that sea voyages might improve the health of King George VI, and a contract was placed with John Brown and Company (Clydebank), Limited, in February, 1952. As the ship was intended to be used as a hospital ship in the event of war, size was a matter of importance. As constructed, the Britannia had an overall length of 412 ft. 3 in. and a maximum moulded breadth of 55 ft. The light displacement (i.e., without fuel, water or stores) was 3,990 tons, and the load displacement, with 330 tons of fuel and 120 tons of fresh water, 4,715 tons. Her gross tonnage was 5,769 tons. The main propelling machinery developed 12,000 shaft horse-power, which gave a speed of 22¾ knots on trial. The endurance with 330 tons of fuel oil was 2,100 miles at 20 knots or 2,400 miles at the economical speed of 15 knots. Extra tank capacity was provided for long passages, which would bring the oil capacity up to 490 tons and the fresh water to 195 tons. Provision was made for refuelling at sea at the rate of 250 tons an hour.

The structural plans, in their final form, were approved by Lloyd's Register of Shipping as well as by the Admiralty. She was built under Lloyd's survey as well as that of the Admiralty. The main transverse watertight bulkheads extended to the upper deck and had no openings below the lower deck. The usual access through watertight doors between the machinery space and the shaft tunnels, customary in merchant ships, was omitted. Special arrangements were made for the rapid clearance of water which might be shipped on the upper deck. The design of the main machinery was based on that of the channel steamers Arnhem and Amsterdam, developed by Pametrada in conjunction with John Brown and Company; it consisted of two sets of turbines with single-reduction gearing, each set developing 6,000 shaft horse-power at 285 r.p.m. of the shafts. Four-bladed propellers were fitted. The starboard propeller was found on trial to "sing," and the blade edges were fined to prevent it. Considerable improvement resulted, though a weaker note persisted, but it occurred at a speed below any that was likely to be used on passage. The lack of vibration throughout the ship justified the decision to fit propellers with four blades, and the general seaworthiness of the vessel verified the model experiments among waves which were undertaken at Haslar. In heavy weather, with the ship rolling 40 deg., "out to out," the Denny-Brown stabilisers reduced the roll to 10 deg.

The accommodation for the Royal party (or, alternatively, for the hospital, which would take 200 patients) was in the after part of the ship, and that for the officers and crew was forward. Working spaces such as the galley and laundry were grouped amidships over the main machinery spaces so that the exhaust ventilation could be led up inside the funnel. The accommodation at the after end of the ship, which would be used for hospital purposes when she was employed as a hospital ship, was fully air-conditioned. The air-conditioning units, and also the fans used for normal ventilation, were grouped in acoustically-lined chambers to keep the noise level to a minimum. The funnel design, developed in the Aerodynamics Division of the National Physical Laboratory, had proved most effective. The funnel was designed also to serve as a derrick post, the derricks being grouped amidships to enable this to be done. The sun deck aft was strengthened to enable a helicopter to land on it, this being a requirement for hospital service.

To be continued.

CAMBRIDGE UNIVERSITY ENGINEERING DEPARTMENT

Education and Research

The report on the Department of Engineering of Cambridge University for the year 1952-53, which has been prepared by Professor J. F. Baker, the head of the Department, is divided into six sections, of which the first is devoted to teaching, administration and general affairs and the second to research. Other sections cover workshops, donations for the Department's appeal, gifts of plant and equipment and works published by members of the Department.

Those in residence during the year numbered 643 excluding research students, an increase of 19 over the previous year. In Part I of the Mechanical Sciences Tripos 147 students obtained honours, 16 of these in the first class and, in addition, 14 proceeded to the Ordinary B.A. Degree; in Part II of the same Tripos 36 obtained honours, one with distinction, and 14 failed. Ninety students were awarded the Certificate of Proficiency in Engineering Studies. The 1952 entry included 44 commissioned officers from Service technical branches. Of the nine students attending the post-graduate course in Structures and Materials, one was an American and one a Canadian; the remainder came from the British electrical and chemical industries, the National Coal Board and from boiler-making and civil-engineering firms.

Staff changes in the Department included the appointment of Mr. W. A. Mair to the Francis Mond Professorship of Aeronautical Engineering in succession to Professor Sir B. M. Jones. Professor H. W. Emmons of Harvard University worked in the Department as a Fulbright Professor and Professor Hunter Rouse, Director of the Iowa Institute of Hydraulic Research, paid a short visit and gave two lectures.

The outstanding event of the year was the visit of H.R.H. the Duke of Edinburgh on November 13, 1952, to declare the new building open. The additional rooms, theatres and laboratories have proved of great service and are in complete and regular use.

In the field of aeronautics, wind-tunnel experiments on the behaviour of turbulent boundary layers with distributed suction have continued. Further work has been carried out on the Pitot-tube method of measuring the skin-friction stress on a surface with a turbulent boundary layer, and a paper on this subject has been submitted to the Aeronautical Research Council. A paper has also been published on a method for calculating the lift of an aerofoil, taking account of the boundary layer.

The Professor of Electrical Engineering, Professor E. B. Moullin, has continued his study of the theory and performance of radio aerials and has published a paper on the current induced in a conducting ribbon by a current filament parallel to it. Progress has been made with the investigation of the magnetic properties of steel, especially concerning their relation to mechanical stress. An electric strain-gauge measuring set has been designed for measuring peak strains in fatigue testing.

In hydraulics, research on cavitation bubbles has been embarked upon with aid from the Admiralty. The materials department has completed an investigation for the Ministry of Supply into the effects of welding and notches on the strength and fracture of light rolled sections of certain steels at low temperatures. In the province of mechanics work is in progress on the behaviour of a flexible rotor running in bearings in an elastic frame. A long-term programme of research into the behaviour of non-linear servo-mechanisms and control systems has also been inaugurated.

STRESSES IN GEARS

In the field of stress analysis, emphasis has been on photoelastic investigations. With the support of the Mechanical Engineering Research Board of the D.S.I.R., the photoelastic study of dynamic stresses in gear teeth has continued, especially with respect to the consequences of errors in form or spacing. It is hoped to extend the usefulness of stress-optic methods to problems of inelastic behaviour, and work with this object has begun.

The recently installed 60-ton Schenck fatigue-testing machine has been used to investigate the fatigue-strength – according to the method of deposition – of end-fillet welds. Theoretical and experimental research into the behaviour of mild-steel beams under dynamic loading has commenced. Papers on the stability in bending of slightly corrugated plates, and others discussing the economies achieved by the plastic method of designing steel frames have been published. Work on welded connections under impact loading has continued. Further tests upon real soils with apparatus for applying a plane shear strain to the samples have been performed.

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SUPERVISING ELECTRICAL ENGINEERS' ANNUAL DINNER

The annual dinner of the Association of Supervising Electrical Engineers was held at the Connaught Rooms, London, W.C.2, on Friday, April 2, with the President, Mr. C. T. Melling, in the chair.

Among the principal guests were Sir Miles Thomas, chairman of the British Overseas Airways Corporation, who proposed the toast of "The Electrical Industry," and Mr. H. Bishop, C.B.E., President of the Institution of Electrical Engineers, who responded to it. Sir Miles Thomas said that the electrical industry's services to the community in domestic, medical and industrial fields provided an enormous contribution towards our living standards.

He reported that his own industry, which had hitherto operated at an annual loss of several million pounds, was making to-day a substantial profit. "We have been nationalised not sterilised," he said. Research was the key to progress and profited greatly from the encouragement of such associations as the one whose guest he was on this occasion.

Mr. Bishop, in his response to the toast, said that 1953 had also been a good year for the electrical industry but he felt it dangerous to overlook the imminent need for re-equipping homes and factories. He applauded the industry's successful exporting year but regretted the ignorance outside the industry of its requirements. The Institution of Electrical Engineers helped with respect to training and recruitment but the number of young entrants was still insufficient. In this great electronic and power-production age, the needs of the electrical industry must be presented vividly to the public.

Mr. J. Flood, national chairman of the Association, also responded to the toast. The President proposed the toast of "Our Guests" and in his speech expressed regret that the works of power engineers should be so frequently subjected to public disapproval for alleged marring of scenery and other similar reasons. Mr. J. Eccles, C.B.E., deputy chairman of the Operations Branch of the British Electricity Authority, responded.

BOOK REVIEWS

Foundations. Civil Engineering Code of Practice No. 4 (1954). *The Institution of Civil Engineers, 1 Great George-street, London, S.W.1.* (15*s.* post free.)

This Civil Engineering Code of Practice, the fourth in the series, deals with foundations for the normal range of buildings and engineering structures but not with special foundations for structures of unusual type, size, or sensitivity. On the other hand, though the Code might not cover such foundations specifically, it will provide an excellent basis for examining any problem likely to occur in connection with them.

Perusal of this and other Codes of Practice gives rise to the thought that they may soon replace the conventional text-book. Their advantages are many: prepared by a committee of experts, submitted for comment to leading authorities and to professional and industrial organisations intimately concerned, the Codes have a basis of sound preparation which no text-book written by one or two authors can have. As works of reference, their form of presentation in numbered paragraphs compares favourably with that of normal text-books.

The shortcoming of the Codes, as compared with a good text-book, is the absence of well-documented examples of work successfully carried out. Moreover, though the Code gives clear definitions, and, as is to be expected, states the permissible stresses, it is not over illustrated. The number of drawings is sufficient, however, for the intended purpose of a Code of Practice.

The Code is divided into ten parts. Part 1 deals with the general principles of design in relation to bearing pressures and earth pressures. Parts 2, 3 and 4 are concerned with more detailed considerations of the design and installation of the main types of foundations. Parts 5 to 9 relate to site operations and to construction proceedings involved in foundation engineering. Part 10 discusses the durability of the various materials employed in foundation structures and indicates some of the steps which may be taken to prolong their life.

This last section, concerned with the durability of timber, metal and concrete structures, contains some well-presented information on the action of marine borers on timber; on bacterial and electrolytic corrosion of metals and possible methods to be adopted for their protection; and on the action of sulphate salts, pure and acid natural waters, industrial effluents and other causes of destructive effects on concrete.

Writing English. By D. J. GRAHAM-CAMPBELL. *Edward Arnold and Company, 41 Maddox-street, London, W.1.* (8*s.* 6*d.*)

Engineers as Writers: Growth of a Literature. Edited by WALTER J. MILLER and LEO. E. A. SAIDLA. *D. Van Nostrand Company, Incorporated, 250 Fourth-avenue, New York, N.Y., U.S.A.* (4·25 dols.); and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (32*s.*)

Engineers and scientific workers in general have been widely accused of being unable to express themselves in acceptable English, but it may be suspected that the dissatisfaction felt by many non-scientific readers has its origin partly in the deplorable lack of any broad scientific ideas exhibited even by educated laymen. A scientific writer expresses himself in terms of certain fundamental concepts which, in the Twentieth Century, should be common to all educated people; unfortunately they are not. This is not to claim that engineers and their like write better English than the average non-technical author; it is merely to suggest that, perhaps after all, they do not write worse. There is plenty of bad non-scientific writing.

After this protest, it may be admitted that any instruction in the manipulation of their own language which engineers can be induced to assimilate will be of value. Many books have been published, mainly in America, dealing with

the writing of what is described as " technical English," but, as there is no difference between good technical writing and good non-technical writing, a welcome may be extended to Mr. Graham-Campbell's fascinating volume. He is an Eton College master and is not primarily concerned with the instruction of scientific workers; the greater part of the book deals with essay writing, but a section is concerned with what he terms " the article ", which may be taken to indicate the type of descriptive compilation with which engineers are more usually concerned.

As an illustration of descriptive writing, an article by Professor J. B. S. Haldane is reprinted. This may be precise, but we would not have chosen it as an example of elegant, or even wholly-correct, English. It is not, however, to this article that we would direct the attention of young engineers. The book contains a series of essays, the authorship of which ranges from Francis Bacon to Sir Winston Churchill and Miss Rose Macaulay. These are accompanied by comments of value, dealing with construction, the nature and purpose of paragraphs and sufficient information about punctuation to guide the beginner without confusing him. One of the handicaps under which many young engineers suffer is poverty of vocabulary; the remedy is general reading. Those whose education has been almost wholly technical are recommended to read every word of this book, more than once. It smooths the path of the neophyte by leading him to the essay via a series of short stories.

In a sense, the purpose of the second book, the title of which is given above, is the same as that of the first. In its own words, it " has been written for the purpose of motivating engineering students by a study of the structure and style employed in reports by men of eminent engineering stature." Although we suspect that Mr. Graham-Campbell would disclaim any intention of " motivating " anybody, both books essentially rely on example as the basis of instruction. *Engineers as Writers* consists of reprints of 15 reports or addresses, the first by Vitruvius on " De Architectura " and the last by Arthur E. Raymond on " The Well-Tempered Aircraft," taking in on the way communications by Smeaton, Rankine, Parsons and other great engineers. The various contributions are accompanied by comments on construction and language. In the management and arrangement of subject matter, and the subjection of unessential detail to broad considerations, many of these contributions furnish the student with good examples. The language of the early reports is, however, that of the translators not of the original authors. The English of the selection from " De Re Metallica " is that of Mr. and Mrs. Herbert Hoover, not of Agricola. Apart from any service which it may render as an instructional manual on writing, this interesting volume is of value by bringing together a number of important historical treatises, covering a wide engineering sphere, some of which are not likely to be easily accessible to the ordinary reader.

* * *

BRITISH STANDARDS

The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.

Straight-Sided Splines and Serrations. (12*s.* 6*d.*, post free.)

The dimensions of straight-sided, bottom-fitting, shallow and deep splines produced in holes or on shafts having a nominal size from $\frac{1}{8}$ in to 6 in., together with the dimensions for straight-sided 90-deg. coarse serrations having a nominal diameter from $\frac{1}{4}$ in. to 6 in. are presented in British Standard, B.S. 2059. Particulars of full-form " go " plug gauges for shallow and deep splines and " not go " plug gauges for the major diameter are also specified. For the greater convenience of the user, the Standard is divided into two parts, the first dealing with splines and spline gauges and the second with serrations and serration gauges. The new Standard is intended to supersede four previously-issued specifications for splines and serrations, relating to general engineering, B.S. 46: Part 2: 1929; the motor-car Standard, B.S. 5015: 1927; and the aircraft Standard, B.S.-A19 and A20. In the new Standard particular regard has been paid to producing a pleasing and attractive layout, especially ensuring that, regardless of the size of a table, the appropriate illustration conveniently faces the reader on the same or on an opposite page. A companion Standard dealing with involute splines is now being prepared.

Sizes of Sensitised Material for Recording Instruments.
(2*s.* 6*d.*, post free.)

A revision of B.S. 1193 : 1945, covering light-sensitive film and paper for recording instruments, which revision has now been issued, supersedes also B.S. 865 : 1939, a specification dealing with 70 mm. perforated film for recording purposes. The perforation pitch of this film has been brought into line with that for the other film sizes. Another new feature in the present edition is the inclusion of 80-mm. film used in mass radiography; this size is suggested as the preferred standard for future recording apparatus requiring a film width from 70 to 100 mm. In addition, the method of specifying dimensions for perforated materials has been revised to conform to the method of measurement used in their production.

Resistance of Conductive and Anti-Static Rubber Products. (2*s.* 6*d.*, post free.)

A newly issued Standard, B.S. 2050, covering the resistance of conductive and anti-static rubber products, is complementary to B.S. 2044 which deals with laboratory tests for resistivity of conductive and anti-static rubbers. The new publication gives the resistivity limits for anti-static tyres for vehicles and for anti-static products for use in hospitals, together with methods of testing the actual products.

TRADE PUBLICATIONS

Oscilloscope and Pulse Equipment. A. E. Cawkell, 6-7, Victory Arcade, The Broadway, Southall, Middlesex, has issued a booklet describing his double-beam oscilloscope, pulse-generator, and wide-band amplifier units.

Steel Fabrication, Press Brakes and Guillotines. A booklet has been published on behalf of the Triplex Group of engineering companies by Weldall and Assembly, Ltd., Old Wharf-road, Stourbridge, Worcestershire, and Stern and Ball, Ltd., Warstock-road, Birmingham, 14. In it are described and illustrated examples of heavy and light steel fabrication and " Eldair " press brakes, guillotines and shears.

Electromagnetic Brake. Lancashire Dynamo & Crypto, Ltd., Willesden, London, N.W.10, have issued a leaflet describing a 4-in. electromagnetic brake now added to their range. This brake is designed for direct mounting on the motor and has a maximum frictional torque of 7 lb.-ft. This makes it suitable for motors up to 2 h.p. and 1,500 r.p.m.

Centrifugal Fan. A leaflet published by Musgrave & Co., Ltd., St. Ann's Works, Belfast, describes their " N " type fan. Fitted with backward curved aerofoil blades, the fan has a static efficiency between 80 and 82 per cent. under B.S. test conditions.

Scaffolding. Stephens and Carter, Ltd., 731 Harrow-road, London, N.W.10, who specialise in builders' plant and, in particular, tubular scaffolding, have sent us a booklet on the subject of scaffolding. Illustrations of scaffolding for spires, towers, buildings and bridges, and an illustrated glossary of terms and a brief summary of safety regulations are given.

Valves for Oil. We have received from Alley and Maclellan, Ltd., Worcester, a copy of their latest indexed catalogue illustrating and describing the various types of wedge, globe, swing-check, drilling and flow-line valves which they manufacture for the petroleum industry.

Paint-Reconditioning Machine. A machine for reconditioning small cans of paint that have been in store for long periods, known as the Steel-Shaw paint rejuvenator, is described briefly in a leaflet issued by Steel and Cowlishaw, Ltd., Cooper-street, Hanley, Stoke-on-Trent. Unopened cans of capacity from one pint to one gallon are clamped upside down in holders on the machine and are subjected to violent mechanical agitation which restores the paint to its original condition without any loss of quality. The machine is driven by a $\frac{1}{2}$-h.p. motor.

Lubricants. Rocol, Ltd., Ibex House, Minories, London, E.C.3, have issued five publications describing respectively their anti-scuffing paste and oil incorporating molybdenum disulphide; a reamer, tap and drill cutting compound comprising 100 per cent. chemical additive for use under extreme tool pressures; a wide range of molybdenised lubricants and cutting oils; watch and clock oils; and Kilopoise extreme-viscosity lubricants for use as damping and sealing compounds in the instrument industry.

Presses, Pumps, Sugar Plant and Cranes. Plastics moulding presses; baling presses for hides, jute and cotton; hydraulic pumps; evaporators and heat exchangers for sugar processing; and various forms of crane are among the extensive range of plant described and illustrated in a booklet and pocket of leaflets sent to us by Fawcett, Preston & Co., Ltd., Bromborough, Cheshire. In it are also shown examples of steel fabrication and sheet metal work made by that company.

BOOKS RECEIVED

Management Education in American Business. By LYNDALL F. URWICK. *American Management Association*, 330, *West 42nd-street, New York* 36, *N.Y., U.S.A.;* and *Bailey Brothers and Swinfen, Limited*, 46, *St. Giles High-street, London, W.C.*1. (12*s.*)

Water Engineer's Handbook, 1954. Compiled by the Staff of " Water and Water Engineering." *The Colliery Guardian Company, Limited*, 30-31 *Furnival-street, Holborn, London, E.C.*4. (18*s.*)

Alternating Currents. By L. T. AGGER. Second edition. *Macmillan and Company, Limited, St. Martin's-street, London, W.C.*2. (8*s.* 6*d.*)

Statics and Strength of Materials. By ROLAND H. TRATHEN. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.;* and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (60*s.*)

Stress Concentration Design Factors. Charts and relations useful in making strength calculations for machine parts and structural elements. By R. E. PETERSON. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.;* and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (68*s.*)

Mathematics in Action. By O. G. SUTTON. *G. Bell and Sons, Limited, York House, Portugal-street, London, W.C.*2. (16*s.*)

The Physics of Experimental Method. By H. J. J. BRADDICK. *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (35*s.*)

Geometry of Construction. By T. B. NICHOLS and NORMAN KEEP. Second edition. *Cleaver-Hume Press, Limited*, 31 *Wright's-lane, Kensington, London, W.*8. (8*s.* 6*d.*)

National Smoke Abatement Society. Proceedings of the Glasgow Conference, 1953. *National Smoke Abatement Society*, 30 *Grosvenor-place, London, S.W.*1. (7*s.* 6*d.*)

British Institute of Management. Report of the Annual Conference, Harrogate, 1953. *British Institute of Management, Management House*, 8 *Hill-Street, London, W.*1. (7*s.* 6*d.*)

Public Cleansing (Refuse Collection and Disposal, Street Cleansing) Costing Returns, 1952-53. Ministry of Housing and Local Government. *H.M. Stationery Office, Kingsway, London, W.C.*2. (3*s.*)

Men and Machines. Photographed by WALTER NURNBERG. Published by the Author, 18 *Cornwood-close, London, N.*2. (25*s.*)

Foundations. Civil Engineering Code of Practice No. 4 (1954). *The Institution of Civil Engineers*, 1 *Great George-street, London, S.W.*1. (15*s.*) (Reviewed on page 487.)

Form in Engineering Design. By J. BERESFORD-EVANS. *Geoffrey Cumberlege, Oxford University Press, Amen House, Warwick-square, London, E.C.*4. (10*s.* 6*d.*)

The Electromagnetic Field in its Engineering Aspects. By G. W. CARTER. *Longmans, Green and Company, Limited*, 6 *Clifford-street, London, W.*1. (35*s.*)

DESIGN FOR AN EMBEDDED THERMOCOUPLE

STEAMTIGHT UNITS FOR PLATES, TUBES OR DRUMS

By D. E. Upton, B.SC. (ENG.), A.C.G.I.*

Metal temperatures in the pressure parts of steam-generating plant or similar equipment may generally be determined by means of base-metal thermocouples. A common method of attaching the couple is to complete the hot junction in the metal surface by peening the ends of the thermocouple wires into shallow clearing holes, the wires being led away through the surrounding gas space. The reliable life of a thermocouple of this type, however, is limited by mechanical failure, accelerated by external action such as soot blowing, and also by changes in characteristics due to the chemical effect of some flue-gas constituents.

As an alternative, the installation of a thermocouple within the pressure vessel itself would seem attractive, provided the couple and lead are protected from the working fluid in the vessel. This can be achieved in large vessels, such as boiler drums, by employing thermocouples of normal type completely enclosed in a pressure-tight case such as a steel tube. It has been found difficult, however, to fit a satisfactory thermocouple in a confined space, such as the interior of a superheater tube, where not only must the electrical and mechanical properties of the equipment be adequate, but also dimensions must not be such as seriously to obstruct the tube. The procedure described below is brought forward as a solution to the problem.

A mineral-insulated base-metal thermocouple wire contained in a metal sheath is now commercially available. Iron-constantan and chromel-alumel couples in cupro-nickel sheaths of $\frac{1}{4}$ in. outside diameter have been successfully employed in the development of this technique where a typical installation has been the fitting of a thermocouple to measure the metal temperature of a superheater tube of $1\frac{1}{4}$ in. outside diameter with a wall thickness of $\frac{1}{8}$ in. This example demonstrates the suitability of the thermocouple for use in a restricted space. It has been found possible to seal the metal sheath to, and complete the hot junction in, the tube wall itself or to form the hot-junction assembly in a terminal cap which can be attached where desired.

TUBE WALL AS ELEMENT OF COUPLE

Fig. 1 shows the hot junction and sheath seal made in the tube wall. The two wires of the couple are passed through separate holes and the inner side of the tube wall is recessed to receive the sheath. The whole is secured and sealed by silver solder. The holes for the wires are relieved to bring the hot junction close to the outer surface of the tube. Access to prepare the tube wall and attach the thermocouple is provided by a hole diametrically opposite, which may be closed by a screwed and welded plug, as shown.

Fig. 2 illustrates the method of using a terminal cap which was adopted as a development of the construction previously described. It has the advantages that only the hole to receive the end of the cap need be drilled in the tube and that the greater part of the preparation of the thermocouple can be completed before installation. The sheath is secured by silver solder to the cap, but in this the wires are each reduced to a half-round section and contained in a single hole. To facilitate installation the cap is made of greater length than is required to penetrate the tube wall the surplus material being cut off and the cap sealed to the tube wall by a bead of weld metal, thus ensuring the fusion of the thermocouple wires at the hot junction. An eyelet or a tapped hole is provided at the end of the cap to assist in placing the cap in the hole in the tube wall. It has been found advantageous to drill this latter hole at an angle from the perpendicular in order to reduce the strain on the thin sheath of the thermocouple lead where this is set into the wall.

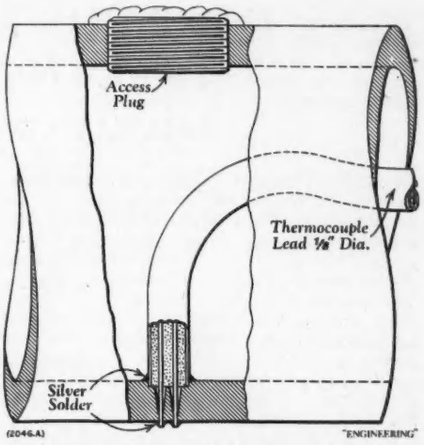


Fig. 1 Hot junction and sheath seal made in tube wall. The junction is brought close to the outer surface by relieving the holes for the wires.

THERMOCOUPLES FOR HIGH TEMPERATURES

Modern operating conditions may necessitate measurements of temperatures up to 1,150 deg. F., which will require the use of thermocouple wires sheathed in a heat-resisting alloy. For such conditions, where an austenitic sheath would be employed for attachment to a terminal cap of similar material, silver soldering or brazing would not appear to be suitable for sealing and an alternative method is suggested in Fig. 2, using a mechanical connection similar to a ferruled pipe coupling. The terminal-cap assembly lends itself to the fitting of thermocouples inside thick-walled vessels, when the end of the cap is threaded and screwed into a tapped hole in the vessel wall. An application of this sort has been the determination of the temperature in the base of a steam separator with a steam temperature of 925 deg. F.

To bring out the leads of the sheathed thermocouple wire, means may be adopted such as the use of a stuffing box or sealing within a hollow bolt passing through the pressure vessel wall; or, for permanent installation at a high working temperature, some construction which may be seal welded.

For temperatures where the iron-constantan couple is suitable, an independent approach has been made on the Continent. A constantan wire insulated by a woven-glass sleeve has been employed in a mild-steel tube which serves as the complementary metal as this tube is welded to the vessel wall under investigation. The lead is taken through the vessel wall as convenient.

It has been found in practice that the internal thermocouple may indicate a temperature slightly lower than the true metal temperature due to the cooling effect of the fluid within the pressure vessel when heat transfer is taking place. An estimate of the error may be made by comparison with the temperature indicated by an external thermocouple which will read high under these conditions. In the particular applications employed in the development of these thermocouples it has appeared that errors have been less than 20 deg. F. at a temperature of 850 deg. F.

PROBABLE LIFE OF THERMOCOUPLE INSTALLATION

Experience with this technique has been obtained over the past two years as opportunity has offered on experimental work, so that the probable life of an installation of this type in commercial service has not yet been determined. Couples have given satisfactory service for more than six months in continuous operation under fluctuating conditions and early failure after this period was not expected. It is known that the employment of non-ferrous metals in contact with many steels under creep conditions may give rise to failure owing to attack of the steel, but no failure from this cause has been experienced. The suggested use of a mechanical coupling between the thermocouple and the terminal cap should obviate this risk.

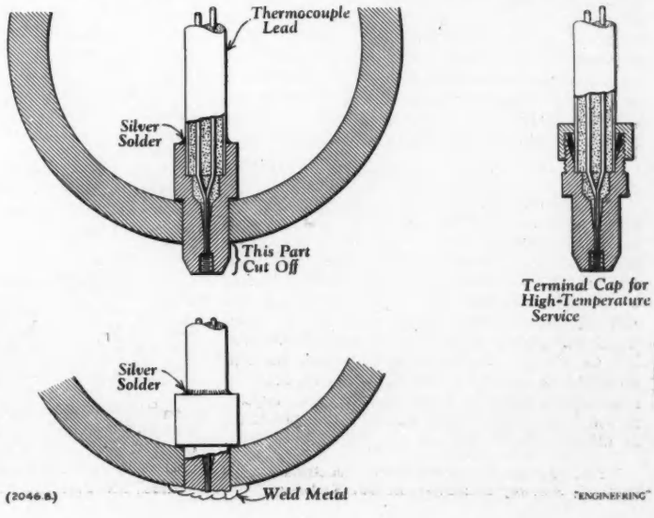


Fig. 2 An internal thermocouple made with a hot-junction terminal cap. On the right is a terminal cap made with a pipe-coupling type of ferrule and nut.

* Service Engineer, Babcock & Wilcox Limited.

A COMPARISON OF ELECTRIC TRACTION SYSTEMS

RAILWAY CONGRESS REVIEW

Two reports, in which the technical and economic basis of the electric-traction systems now in use are investigated, will be submitted at the 16th session of the International Railway Congress Association, which is to be held in London from Wednesday, May 19, to Wednesday, May 26. The *questionnaire* from the replies to which these reports were prepared, asked whether there were relevant reasons for preferring one system to another, particularly in regard to power supply, overhead-line and fixed track installations, motive-power units and working and maintenance costs.

In the first report Mr. S. B. Warder* recalls that in the 20 years intervening since a similar question was posed at the Cairo congress in 1933, significant changes have occurred in the economic affairs of railways. Progress has been made with the electric-traction systems then available, and an important new system, using 50-cycle alternating current at about 25 kV on the contact line, has emerged from its first trials on the Hungarian and German railways. It is employed on one French line and in the Belgian Congo and is being adopted for the electrification of important lines in north-east France. During the same period other forms of railway motive power have established themselves and have profoundly affected the requirements for successful railway operation. It is also significant to record that during the period under review four reports, each advocating a different system for the particular conditions on the railway to which they refer, have been issued.

NO "BEST" SYSTEMS

Comparisons indicate that some systems show up well for fixed installations and less well for motive-power units. In others the position is reversed. On long lines with relatively infrequent trains through country presenting few difficulties in obtaining clearances for high-voltage contact lines, a system which is "best" for fixed installations and less good for motive-power units has obvious advantages. Where, on the other hand, the network is complicated and traffic heavy (so that large numbers of locomotives and other rolling stock are required) and the route passes through towns and suburban and inter-urban country (where constructional difficulties can only be overcome at vast expense) the system which is best for motive-power units is obviously at an advantage.

Where a railway may have been more or less completely electrified on one system before a new and better system became available, the latter might need to have very great advantages to make it economically sound to scrap the former. At the other extreme, where a small railway, not yet electrified, exists between two larger systems electrified on a system which is neither technically nor economically best for the small railway, considerations such as inter-running would certainly determine the choice.

COST FACTOR

Another consideration of a general nature is that unless low capital costs go hand in hand with low running costs, it is difficult to assess which system is economically best. In fact, what could be shown to be the "best" system in the present state of uncertainty about the stability of monetary values and labour rates might not prove to be the best throughout the life of all the assets. Closely allied to this difficulty is the fact that the relative costs of materials of different kinds vary greatly. Again, in some countries labour is cheap and plentiful, in others some materials are scarce and dear.

* Mr. Warder is Chief Officer (Electrical Engineering), Railway Executive, British Railways.

Clearly, in these circumstances it is unlikely that one system would be best for all. While, therefore, *a priori*, none of these questions prevent a sound decision being reached about a particular electrification at a particular time, they do suggest that no one system can be preferable for all railways at this or any other time.

CASE FOR ELECTRIFICATION

This view is confirmed by a consideration of the case for electrification. In all parts of the world there are lines which will never pay their way and will be closed down unless strategic or political exigencies demand their retention. The electrification of such lines need not be considered. Many lines of somewhat higher traffic densities can best be served by Diesel cars, although where oil is not a national product such lines begin to be interesting from the point of view of electrification. In this connection it should be recognised that the field for competition between Diesel, steam and electricity is much more restricted than is often thought, and that in a properly conceived electrification scheme there is a place for all kinds of Diesel motive-power units.

Lines of higher traffic density and lines on which a high traffic density could be stimulated, are potentially of interest from the point of view of electrification. For such lines the motive-power unit and rolling stock are of fundamental, and questions of power supply and fixed installation of only secondary, importance. Circumstances other than traffic density sometimes warrant electrification, and the existence of lines of this kind may have an important bearing on the choice of system.

MOTIVE-POWER UNITS

In dealing with motive-power units study has been restricted to the 1,500-volt and 3,000-volt direct-current and to the 11 to 25-kV alternating-current systems at $16\frac{2}{3}$, 25 and 50 or 60 cycles. Motive equipments of proved success are available for the two direct-current and the low-frequency alternating-current systems. Direct-current equipments tend to be cheaper in first cost and maintenance than those for alternating current of similar performance, and the lower voltage direct-current equipment presents fewer design problems and is likely to be more flexible and reliable in service. Resistance notching is employed on all standard direct-current systems. This involves the provision of considerable weights of resistance material and the dissipation of large amounts of power when starting heavy trains. These losses may, however, be kept to a minimum by arranging for the resistances to be cut out early in the notching, further speed regulation being obtained by a wide range of field control.

The alternating-current traction motor has an inherent tendency to bad commutation, making it necessary to adopt a low terminal voltage and frequency. The transformer necessary for this purpose has, however, the advantage that it renders the motive-unit equipment independent of the line voltage and introduces a most convenient and economical method of traction motor control.

CONVERSION ON THE LOCOMOTIVE

The reliability and flexibility of the direct-current motor and the advantages of high contact-line voltages render the combination of the two systems by the interposition of a converter between the line and motors attractive. Recently, developments in ionic converters have opened up a new field in this direction and if the problems of clearance from live metal at high voltages, and of "interference," can be satisfactorily settled, there should be a considerable future for this type of electrification, since the reconciliation of the opposing frequency requirements of the supply system and the traction motors becomes unnecessary. Moreover, inter-running with existing direct-current systems is simplified. Other advantages are high energy-conversion efficiency and uniformly high power factor, as well as the possibility of the mass production of standard components and ancillary equipment. If, by these means, first and maintenance costs can be substantially reduced, a type of commercial-frequency alternating-current electrification might be developed which would have a very wide application. On the other hand, the interposition of converting equipment must necessarily affect both maintenance and first costs. It is therefore probably true to say that the direct-current motor with a wide range of field weakening and resistance control, operating at 750 or 1,500 volts, will remain the simplest, cheapest and most reliable form of motive equipment.

Attention may also be drawn to one particular feature which cannot be conveniently achieved with any form of motive power besides electrification. Given sufficient attention to the design of bogies and coach construction, considerable benefits would be derived by operators and the public from the use of improved multiple-unit sets.

POWER TRANSMISSION PROBLEMS

The problems of transmitting power to electrified railways are largely those associated with the general supply network, the operators of which are more likely to be influenced by electrification as a policy than by the type of system employed. The question of sub-station spacing occupies a prominent place in the investigation of both direct and alternating-current systems. This spacing is likely to vary from 5 to 15 miles for 1,500-volt and from 10 to 30 miles for 3,000-volt direct current. With low-frequency alternating current the distances vary from 8 to 90 miles, the substations being supplied either through a separate network or through frequency changers. The first involves costly feeders and the latter expensive substations with rather poor efficiency. The lines are operated at the highest voltages which are considered economically practicable.

With 50-cycle electrification considerable unbalance must occur at the supply point, although this can be mitigated by the use of Scott-connected transformers. With direct-current electrification corresponding care must be taken to avoid distortion by harmonics from the rectifiers. Serious difficulty with power factor is only likely to occur on 50-cycle electrification when 50-cycle motors are used.

FIXED EQUIPMENT

The fixed equipment, comprising the high-voltage feeders, substations and overhead contact lines, constitutes a heavy investment and is the dominating issue, owing to the ever-present problem of raising the required capital sums. The cost of these items in relation to the cost of the railway as a whole is, however, liable to be grossly over-estimated. The wide diversity of the replies concerning the first, working and maintenance costs renders it impossible to make effective comparisons between the systems. The main reasons are that the lines were electrified at different times and that the differences between the systems effectively obscure the differing costs of the methods of electrification. Differing times of electrification mean that the maintenance costs of old equipment on one railway are compared with those of new equipment on another. Effective comparison is, in fact, only possible after minute examination of accountancy methods and adjustments for the size of units. Differences in methods of paying for current and the arbitrary nature of adjusting from one currency to another, which ignores many factors, are two more obstacles to any real comparison between the costs of doing the same work on different railways at one time, and make comparison between different jobs at different times well-nigh impossible.

The conclusion to be drawn from this study supports the view that no one system is likely to be superior to all others in all circumstances. The best system for any given conditions can, however, be determined and the information given in the report, which is based on the experience of 40 years, is valid for this purpose.

The second report on this subject was prepared by Professor Dr. Ing. C. Guzzanti* and is based on replies to a *questionnaire* sent to 66 administrations in Austria, Belgium, Czechslovakia, France, Greece, Holland, Hungary, Italy, Yugoslavia, Luxembourg, Poland, Portugal, Roumania, Spain, Switzerland, Syria, Turkey and Western Germany. Only 37 replies were, however, received, 23 of which stated the administrations concerned were not in a position to answer the questions. In fact, only 14 administrations gave replies which were of any use.

THE PRESENT POSITION

In 1933, the choice of a system for main-line electrification lay between direct-current at 1,500 or 3,000 volts and single-phase at 16⅔ cycles. This is still the position, with the addition of the single-phase system at standard frequency, which has received an important application in Hungary and is being experimented with in Germany (Höllental) and in France (Savoy). The latter, although small in extent and traffic density, is of outstanding interest owing to the large number of studies that have been made and the variety of the solutions adopted. In fact, the results have led France to electrify the Valenciennes-Thionville line and Belgium the Bas-Congo-Katanga Railway on this system.

A long section of the report is devoted to the problem of power supply, in the course of which the question of generating stations and high-voltage lines for the exclusive use of electric traction, substations, regenerative braking and the unbalancing effects on three-phase systems of single phase loads are considered. In another section the overhead line and contact systems are dealt with, reference in particular being made to mechanical stability and minimum clearance. The means adopted to deal with disturbances to telecommunications and electrolytic corrosion are also described. The rolling stock receives equally detailed treatment and the practice adopted in the design of this part of the equipment is shown to be influenced by a number of causes, both technical and operational. An economic examination of the various systems of electric traction is another section of the report in which capital expenditure and running costs are subjected to close analysis. As is usual in these reports there is a great deal of statistical data which is reproduced in convenient tabular form.

RESERVATIONS ON CHOICE OF SYSTEM

As the result of examining all this information it would appear, says Professor Guzzanti, that the 1,500-volt and 3,000-volt direct-current systems as well as the alternating current system at low and standard frequencies are all equally suitable for large-scale railway work. To this general statement, however, some reservations must be made. In the case of direct-current, especially at 3,000 volts, regenerative braking complicates the substation arrangements and defences must be adopted against electrolytic corrosion, especially where stray currents might affect pipes carrying inflammable liquid. Single-phase low-frequency alternating current has the disadvantage that it is necessary to instal either frequency converters or a special distribution system for railway use only. With a single-phase standard-frequency supply, there is a risk of unbalanced loading, while the construction of the locomotives is complicated whether commutator motors or transforming equipment are used. So far, moreover, there has been little experience with the use of this system on motor coaches. In all cases it is necessary to provide adequate protection against disturbance to telecommunication systems.

* Professor Guzzanti is Professor of Electric Traction at the University of Pisa.

It is anticipated, however, that all these drawbacks will be removed by experience. For instance, improvements in the mercury-arc rectifier should enable power to be returned to the feeders. It should also be possible to connect the single-phase low-frequency system to the public mains by the use of static equipment for converting the phase and frequency.

The systems mentioned above all have the peculiarity that the simpler and cheaper the associated fixed installations the more complicated and expensive the rolling stock. Development has therefore taken the form of attempting to reduce the complication and cost of the latter equipment. As the traffic increases the corresponding increases in the rolling stock and the size of the fixed installation do not follow the same law. Both are discontinuous, but the discontinuity is greater for the fixed installation than for the rolling stock. It follows that the traffic conditions, and particularly the possibility of being able to use a small number of trains, are decisive factors in determining the effect which a saving on the fixed installation may have on the total cost of electrification. On the other hand, the operating cost is only dependant on the cost of electrification to a very limited degree. A system, the cost of electrifying which has been high, may therefore be moderately inexpensive to operate. Operating costs, however, tend to increase with the amount of rolling stock and with the sensitivity of the tractive units and substation equipment.

INTER-RUNNING

The use of electric traction raises the problem of the inter-running between railway networks having different systems. This presents itself in different forms according to whether lines belonging to networks already electrified or to be electrified are concerned. If the lines belong to different networks, of which at least one has not carried out an important electrification, then the same system can be extended to the second network, as it may be anticipated that it will be beneficial to use the tractive units of one on the lines of the other. If, however, the two networks have already carried out important electrifications either the locomotive can be changed at the frontier, or a " double-system " used, or the system of one network converted to that of the other. The preferable solution is that which, from all points of view, including the economic, will be most convenient. It, however, seems that the double system is the least convenient and that conversion is the most expensive. In fact, the French Railways state that the expense of converting their direct-current network to single phase would be greater than the savings obtained with a new system. A change of system would be even less convenient in the case of lines belonging to different networks. In fact, the only solution is to change locomotives at the frontier unless the " double system " is improved.

ECONOMICS OF THE STANDARD FREQUENCY SYSTEM

It has often been stated that the use of the single phase standard frequency system reduces the cost of the fixed installation and lowers the threshold of traffic intensity below the point at which electrification becomes convenient. The question may therefore be asked whether it is necessary to forego such electrification for the sake of standardisation when the line for which it is suitable is included in a network which has already made use of another system. Obviously an answer can only be obtained by balancing the advantage of using the most economical system against the disadvantage of having two systems.

If, in fact, a large railway network can be divided into two, one of which is and the other is not electrified; if the two networks have only a limited number of common stations and the non-electrified network carries less traffic per kilometre than the electrified and can be served by a limited number of trains; and finally, if it is possible to organise the operation in such a way that there is a high utilisation of tractive units, the idea that two systems can co-exist must not be lightly dismissed. Definite judgment can only be given after an accurate examination, but evidence may show that the single-phase standard frequency system can be used with economic advantage on the network with less traffic.

* * *

LAND RECLAMATION FROM THE WASH

Hydraulics Research Station Commence a Study

The Fenland, bordering the Wash, is one of the most fertile areas in the country and includes approximately 830,000 acres of that 2 million acres of first-class arable land out of the total of 18 million acres of good agricultural land existing in England and Wales at the present time. Were it not for the various drainage and civil engineering works which have been built over the years, nearly the whole of this 830,000 acres would either be flooded or covered by the sea. Nevertheless, the sea-level relative to the land is rising, which makes the drainage of the area increasingly difficult and the outfalls of the rivers falling into the Wash of added importance.

The Hydraulics Research Station, Wallingford, of the Department of Scientific and Industrial Research, have commenced to carry out research into the problems involved at the request of the Ministry of Agriculture and Fisheries, and it is stated that, as far as can be seen at the moment, it may be possible eventually to reclaim additional areas and to bring a valuable 50,000 acres into the category of first-class arable land.

As early as 1664 it was realised that the outfalls of the Fenland rivers were the key to efficient drainage, although the more important works were not carried out until the Nineteenth Century, when, in 1821 and 1852, the Eau Brink Cut and the Marsh Cut on the River Ouse were respectively completed, and in 1884 the Outfall Cut of the River Witham was also completed.

The Old and New Bedford rivers were excavated in the Seventeenth Century and drained a large part of the Southern Fens, but not without giving rise to new problems, the chief of which was the considerable lowering of the land surface in the peat areas. This lowering is still proceeding and is due to wasting away of the peat through bacteriological action; in places, this wasting away has caused a lowering of levels by 11 ft. during the past 80 years. In the silt areas, which were also drained, the extent of the lowering of the land surface has been much less and these different rates of lowering, which were not foreseen, have now become a principal factor in the problem of draining the Fens.

It is estimated that 75,000 acres of tidal land have been reclaimed from the Wash since the middle of the Seventeenth Century. Some of this land came from improving the outfalls of rivers but most of it was gained by building marginal embankments along the Wash and reclaiming the salt marshes behind them. As the work of reclamation progressed, new embankments were built on the seaward side of the older embankments so that, at the present time, the reclaimed salt marsh is covered by a series of embankments, generally between one-third and half a mile apart, with the original earthworks not infrequently several miles inland. The latest scheme of this type was carried out in 1951, when the Wingland Bank was built to recover 700 acres of salt marsh from the margin of the River Nene; this land is expected to become arable land in the topmost category after ten years of cultivation and treatment.

There are three main problems to be con-

sidered. The first of these is the cumulative lowering of the land surface in the peat areas, which has led to drainage difficulties; the second is the maintenance of the old embankments constructed during the past 300 years; and the third, the most intractable, is the difficulties presented by the outfalls of the rivers.

There are many shoals in the estuaries of the Ouse, Nene and Welland but fewer in the Witham; these shoals constitute obstructions to river flows and give rise to an ever-present danger from flooding by the combination of high river discharges, high spring tides and adverse wind conditions. The disastrous flooding by fresh water in March, 1947, was caused by a combination of these factors.

The Department of Scientific and Industrial Research have been requested to investigate the possibility of accelerating accretion round the Wash to obtain more farming land, but in doing this, the proper draining of the area has to be taken into account as a connected problem. Training works to improve the outfalls of the four principal rivers draining into the Wash have caused rapid accretion in the past, but they have also caused deterioration in the channels downstream of them; as a result, large areas have become available for reclamation but no improvement in the overall drainage position has been produced. One of the main problems, therefore, is to determine a design of river-training which will both cause rapid accretion and improve drainage facilities at the same time; it is considered that it may be possible to do this by taking the Wash as a whole, instead of each river separately, and re-modelling the existing training works in terms of an overall plan.

The work of the Hydraulics Research Station, so far, has been to analyse the past changes to the sea approaches to the Wash and in its central portion, and also to analyse the areas reclaimed in the estuaries and the accretion along the margin. This exploratory work, which will have to be completed before any plan can be suggested, has entailed the study of old maps going back to the end of the Sixteenth Century.

MECHANISING PERMANENT-WAY WORK

ELECTRIC OR PNEUMATIC POWER LINES TO SUPPLY PORTABLE TOOLS?

Superficially, it would appear possible to undertake a far greater amount of the work of the permanent-way departments of the railways by mechanical means than is at present the case in Britain. The difficulties preventing the fuller use of machines, particularly for maintenance work, and the value of mechanising the permanent-way gangs, were discussed recently* by Mr. A. Dean, M.I.C.E., Civil Engineer, North Eastern Region, British Railways.

Mr. Dean began by saying that on his region the permanent-way department had mechanical equipment to the value of about £200,000, or about £35,000 per 1,000 miles of equivalent single track; two-thirds of this was accounted for by cranes, mechanical sleeper tampers and track dischargers. In all, this equipment was driven by engines and motors which together had an output of about 2,000 h.p., and the annual cost of outlay, depreciation, maintenance and provision of fuel for it, when fully used, was about £46,000. This figure represented the yearly earnings of about 120 men. As the total number of men employed in the department was nearly 6,000, it would seem possible to do much more, perhaps even 100 times more, by mechanical means. This, however, was not possible, for three reasons.

First, suitable mechanical means had not yet been devised for carrying out, under track conditions prevailing in the United Kingdom, some of the absolutely essential operations. Secondly, a considerable amount of the men's time or the use of costly transport was needed to get machines to the places where they were required to do work. Thirdly, the facilities whereby the machines could work on the track for a substantial proportion of each week could not be given; unfortunately this related particularly to the bigger and more powerful appliances. Thus it was not possible to obtain a high operating availability from the machines.

The mileage of track in this country where machines could be freely driven under their own power, and in safety, on a strip of land alongside the track was very small. What was most required was a service roadway along the side of the track but neither was it in general available nor could it be provided other than at prohibitive cost. This lack of free access enforced the use of "on-track" machines, but the traffic intensity limited the extent to which effective use could be made of such machines. On the average, the number of trains over each track was about 30 a day. Even where the number of trains might be expected to be workable over one line out of two (under single-line working), the effect on adherence to time schedules might be more serious than could be accepted. The mileage of open lines which were signalled for full-speed operating in either direction was negligible in this country. The introduction of single-line working generally involved tedious delays to trains, particularly freight trains when they had to be reversed to cross over on to the "wrong" line. In consequence, on an extensive mileage of the British Railways use of on-track machines was restricted to periods when a full occupation of the line was obtained.

The lines could therefore be classified into the three following categories. First, lines carrying intensive traffic, generally at high speed, on which it was not possible to obtain occupation during weekdays, either by day or by night, for the systematic and regular use of "on-track" mechanical equipment. Secondly, track carrying medium traffic, where it was possible to obtain possession of the track for sufficient periods to make economic use of mechanical equipment. And thirdly, lines where the traffic was so light that units of mechanical equipment could be freely transferred from place to place.

So far as could be foreseen, the day-to-day maintenance of fast open running lines must continue to be by manual methods, making careful use of measured shovel-packing equipment. But the major repair and renewal operations, which had to be carried out under line-occupation arrangements, must be mechanised to the full. Increasing proportions of this class of track were being laid with flat-bottom rail which had a relatively heavy section it might be possible to dispense with the daily examination on foot of the track.

PORTABLE POWER TOOLS

In concentrated yard areas, main junction stations and heavily worked layouts at big termini, it would never be possible to employ on-track equipment for maintenance work. In these localities, however, there was justification for installing either pneumatic-power lines or electrical distribution lines with many "take-off" points so that portable power tools could be employed. As for fast tracks, major works must be fully mechanised to reduce to a minimum the period during which the track was out of service.

For lines where the traffic was of medium density, Mr. Dean envisaged the provision of a fully mechanised maintenance gang dealing with the requirements of all such lines in a locality. The fixed-length gangs would be as small as possible, sufficient only to patrol and maintain the track on a day-to-day basis.

Heavier maintenance of these tracks would be assisted by the appropriate revision of single-line working rules so that, where mid-morning and mid-afternoon train services were light, trains could be run for considerable distances at normal speeds on the wrong line. The extension of signalling installations to permit working in both directions would also make it easier for the engineer to gain possession of the line with a minimum of upset to traffic operation. It was on this class of light to medium traffic line, where rail life was long, that the elimination of a substantial proportion of the rail joints by welding might be justified by reduced costs in subsequent day-to-day maintenance and where the use of concrete sleepers (at the right cost) was desirable.

Many of the mechanical units allocated to the length gangs could be carried. Heavier units, however, particularly those on rubber-tyred wheels, could be pulled along the cess. It would appear that there was a use for medium-weight mechanical units having one wheel running on the cess rail and a larger pneumatic-tyred wheel in the cess to carry the greater proportion of the weight, so that the entire unit could be quickly cleared from the track.

A difficult problem to resolve on railways was the relatively high cost of maintaining the track when relatively light traffic operated on a section of the line. At the present time, the annual cost of maintaining (excluding renewing) running lines and sidings, ranged from £300 to £1,100 per mile of equivalent single line. It was most probable that where the annual cost of such maintenance was highest, the track maintenance cost bore the least proportion to the revenue earned by the intensive operation of trains over these lines. Conversely, it was likely that where the annual cost of maintaining the track was lowest, the cost of track maintenance bore the highest proportion to the revenue earned by the sparse services operating.

Mr. Dean concluded his paper by referring to the value of mechanisation in respect of complete track renewal. The most economical plain line renewal was the longest which could be carried out as a continuous operation with the maximum use of mechanical equipment. To illustrate the saving made, Mr. Dean said that, during 1950, on the North Eastern Region, the average labour cost per mile for "mechanised" renewals was £1,479, but for those carried out by hand and making use of normal track occupation facilities, the comparable cost was £1,727. Moreover, this took no account of the greater speed with which the mechanised renewals were accomplished.

* "Mechanisation of Permanent Way Work – Where is it Leading?" Paper presented to the North Eastern Region Federation of Lecture and Debating Societies at the York Railway Institute, February 23, 1954.

EXPLOSION SUPPRESSION IN INDUSTRIAL PLANTS

LIGHTER EQUIPMENT OF NEW EXTINGUISHING AND VENTING SYSTEMS

During the past two years, considerable development work has been carried out on the suppression of explosions in industrial plants by the Research and Development Department of the Graviner Manufacturing Company, Limited, Gosport, Hampshire, and many hazards, including certain types of dust explosion, can now be overcome. Work on the first industrial contracts is nearing completion, and interest in the system has been aroused in many countries, notably in Sweden in connection with fuel test chambers, and in France, for fuel storage systems and engine test plant.

The principle of the Graviner system of explosion suppression, invented by Mr. W. G. Glendinning and Mr. A. M. MacLennan, and engineered in the first place by Mr. A. Mathisen, managing director of the Graviner Company, was described in ENGINEERING, on page 11 of volume 173 (January 4, 1952). Since August, 1952, Graviner industrial explosion-protection development has been under the control of Mr. H. R. Maisey. It may be recalled briefly that, in its original form, the system was intended for use in closed vessels and comprised a highly-sensitive pressure detector which sensed rates of pressure rises of the order of 5 lb. per square inch per second, and transmitted an electrical signal which fired a detonator housed in the base-plate of a hemispherical distributor cup containing suppressing fluid. The firing of the detonator fractured the frangible hemisphere, and the suppressing fluid was sprayed in a blanketing cloud suppressing and extinguishing the flame.

The system has now been extended to protect vented tanks and ducting, and the detection element has also been used for operating a venting system which for certain large-scale applications may be preferable to suppression. Among the applications for which the Graviner system is particularly suited may be mentioned the protection of Diesel engine and compressor crankcases, fuel transporters, vehicle and small-craft fuel tanks, catalytic chemical processes, grinding and pulverising plants, cyclones and filters, electrostatic precipitators and any plants where finely-divided explosive dusts and powders are handled. These methods of protection may have far-reaching effects on future plant design, as a result of the possible reduction in the maximum pressure for which the vessels required need to be designed and the consequent saving in materials.

PNEUMATIC DETECTOR RESPONDS TO RATE-OF-PRESSURE RISE

The early type of detector comprised a pair of sensitive diaphragms embodying a small hole so that they were pressure-balanced unless the rate of pressure increase in the protected vessel exceeded a pre-set value determined by the size of the hole. When this occurred the deflection of the diaphragm closed a pair of platinum contacts and an electric signal was transmitted to the distributor cup.

The diaphragms were separated from the atmosphere of the protected vessel by a rubber diaphragm. This was not satisfactory for applications in high-temperature environments, and in the present type of detector shown in Fig. 1, the pressure-sensing element comprises a single snap-action diaphragm enclosed by a beryllium-copper bellows, which has a much longer life. In the standard detector, intended for use at atmospheric pressure, the detector contacts close when the rate-of-pressure rise exceeds a predetermined low value which need only exceed by a reasonable factor of safety the maximum possible fortuitous rate of rise of pressure in the system. Usually, detectors are calibrated to trip at 5 lb. per square inch per second.

DETECTOR CONTACTS CLOSED AT PRE-SET PRESSURE

In an explosion, the time taken to reach a given pressure is approximately proportional to the cube root of the volume of the vessel in which the explosion occurs. To render the detector suitable for protecting a wide range of vessel capacities, therefore, it must be able to respond also to slower explosions while remaining insensitive to transient pressure rises. This is achieved by fitting the beryllium-copper bellows with an adjustable pressure setting which, when the static pressure increases beyond a predetermined value, between 0·5 lb. and 2·5 lb. per square inch, causes the contacts to close mechanically.

The bellows are guarded from accidental contacts by a nickel-plated brass casing with a perforated end disc. To protect the bellows from contamination, three thicknesses of nylon filter gauze are retained by a perforated cap on the bottom of the casing. The electrical contacts actuated by the bellows are of platinum, to avoid corrosion during the long periods of inaction.

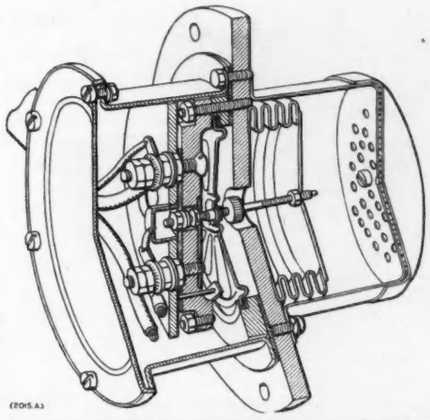


Fig. 1 Industrial explosion detector. A beryllium-copper bellows, responding both to rate-of-pressure rise and to the actual pressure if this exceeds a pre-set value, closes contacts triggering the suppression circuit.

POWER PACK WITH AUTOMATIC EMERGENCY SUPPLY

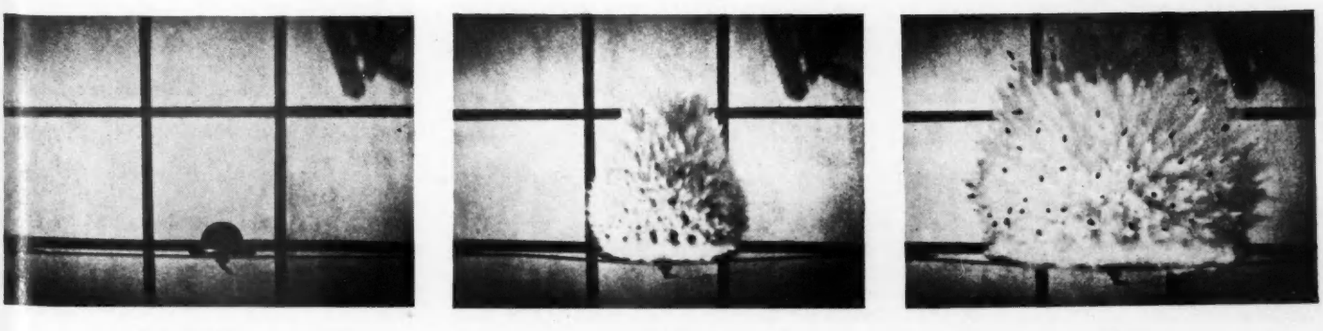
Current for firing the detonators actuating the suppression or venting system is supplied by a power pack, comprising a transformer and a rectifier which charges a condenser. It incorporates its own 150-volt high-tension emergency batteries, which are brought into action automatically should the mains supply fail; a warning light indicates when this has occurred. When the mains supply is restored, the unit reverts automatically to mains operation and the battery is switched off.

When the detector contacts are closed, the condenser discharges through the detonator circuit, and at the same time a warning lamp is illuminated, an alarm signal sounds, and a relay is closed. The latter provides for the automatic shut-down of the plant in the event of an explosion. To safeguard the system, a small current passed continuously through the detonator circuit holds in a monitoring relay in the power pack; any failure in the wiring or power supply to the detonator circuit opens this relay and sounds the alarm signal. The latter is supplied from a separate low-tension battery.

In order to permit personnel to service the protected plant without risk of the suppressors being actuated, the power pack can be isolated by removing a key. Testing switches are also provided for checking and resetting the operation of the alarm signal without firing the detonators.

DETONATOR FIRES EXPLOSION SUPPRESSOR

In the original equipment, the suppressing fluid was stored in a hemispherical plastic cup which was shattered by the firing of a detonator. The plastic hemispheres have now been replaced



a b c

Figs. 2a, b and c. Typical spray patterns from hemispherical suppressor at 1 millisecond, 4 milliseconds and 8 milliseconds.

Fig. 3 5,000-cc. suppressor, containing extinguishing medium. The hemispherical cup is shattered by the firing of a detonator housed in the backplate, and suppressing fluid is distributed in a hemispherical cloud.

by thin silver cups, which withstand high internal pressures more satisfactorily than the plastic cups and can be readily formed with the desired distribution of thickness to give the optimum bursting characteristics and fluid-distribution pattern, Fig. 2. The silver cup is brazed to the brass end-plate housing the detonator. The latter is fired within less than 1 millisecond after the detector contacts have closed, and suppressing fluid is distributed in an expanding hemisphere of fine droplets at a speed of over 200 ft. per second, which is much higher than that of flame travel. Generally speaking, methyl bromide is used as the suppressing medium since it has suitable vapour-pressure characteristics over a wide temperature range.

Recently, to cater for the protection of a fuel-testing chamber for the Royal Swedish Air Board, the large hemisphere illustrated in Fig. 3, which has a capacity of 5 litres, has been developed. Ten such suppressors are fitted in the Swedish installation, in a chamber measuring 8 ft. 6 in. by 7 ft. 10 in. by 9 ft. 6 in. high. The whole chamber can be rendered inert within 100 milliseconds of detection. As recorded recently in a Letter to the Editor, on page 98 of our January 22 issue, a test demonstration of the installation was carried out on December 1, 1953. In this test the chamber was filled with a uniform stoichometric propane/air mixture which was fired by a high-energy spark. The explosion was effectively suppressed, the resultant pressure rise amounting to less than 1·5 lb. per square inch.

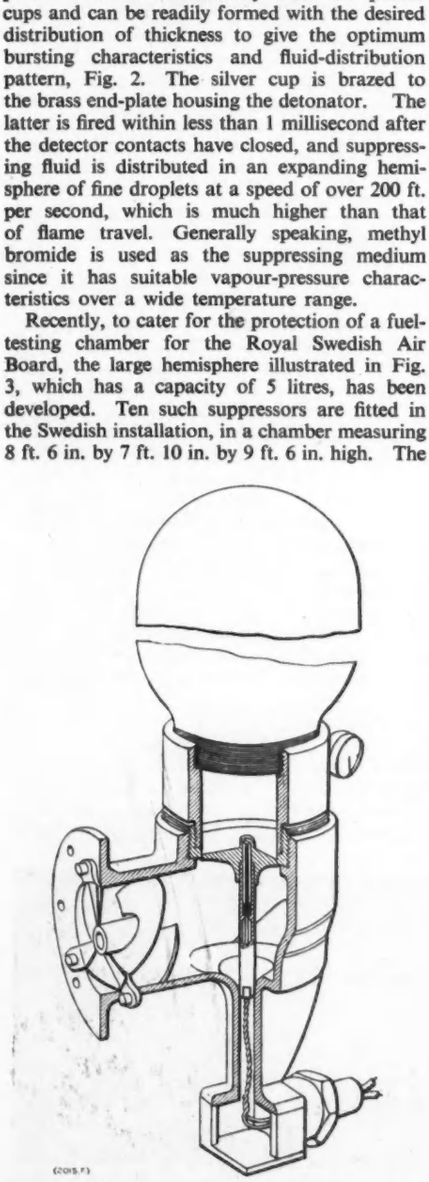


Fig. 4 High-rate discharge bottle, particularly suitable for protecting long ducts since it can give a more elongated distribution of suppressing fluid.

HIGH-RATE DISCHARGE BOTTLE FOR PROTECTING DUCTS

An alternative form of suppressor, particularly suitable for protecting ducts since it can be designed to give a more elongated distribution pattern, is the high-rate discharge bottle, illustrated in Fig. 4. It provides a large volume of suppressing fluid at a flow rate rather lower than is obtained with the hemisphere. Pressurised by nitrogen at 250 lb. per square inch, the fluid is contained in a 3-litre copper bottle sealed by a frangible plug. The bottle is attached to an elbow, in the outlet of which is fixed a " spreader " designed to give the desired distribution pattern for the particular application. The elbow also incorporates a terminal box to which the leads from the power pack to the detonator are attached. On firing the detonator, which is inserted in the neck of the frangible plug, the reaction causes the sealing disc of the plug, the periphery of which has a thickness of only 0·02 in., to break away and to fall into the bottom of the elbow, allowing a free passage for the ejection of the fluid under pressure. The complete discharge occupies 150 milliseconds. A combined high-rate discharge bottle and hemisphere has also been developed, giving a high initial rate of flow followed by a large volume of fluid at a lower rate, but this apparatus has been superseded to a large extent by the 5,000 cc. hemisphere which provides both volume and speed of discharge, and is less costly to manufacture.

PROTECTION FOR GRINDING PLANTS

Among the first practical industrial applications of the Graviner suppression system are two grinding plants. One of these is that of Berk Limited, London Colney, Hertfordshire, for producing powdered sulphur. Here, sulphur is fed into the bottom of a pneumaticaly-operated vertical grinder. The latter is designed to withstand the explosion pressure, but in order to prevent the spread of flame, it is provided with a detector and a 500 cc. suppressor. The ground sulphur powder is blown from the top of the grinder through a long duct into a bag filter. To prevent any possibility of detonation in the duct, hemispherical suppressors are fitted halfway up the latter and at the inlet to the bag filter. Protection for the filter itself is provided by a high-rate discharge bottle. All the suppressors are fired simultaneously by the operation of the detector in the grinder.

Another plant protected by the Graviner suppression system is a wood-flour grinding and pneumatic-conveying installation manufactured by Unipulver Limited, 38 Pryme-street, Hull, which is installed at the works of Wood Flour Millers, Limited, Hull. About two years before this equipment became available, their factory was severely damaged by fire following a wood-flour explosion.

In the Unipulver plant, sawdust is fed into one end of a rotary grinder, from the other end of which the wood flour is extracted by a cyclone. From the bottom of the cyclone the major portion of the flour passes through a rotary gate valve, forming an air lock, into a receiver hopper.

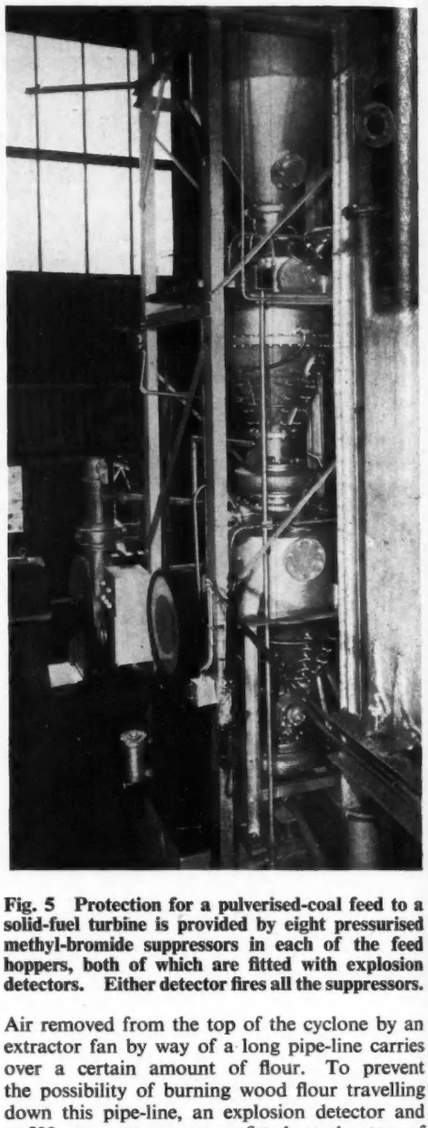


Fig. 5 Protection for a pulverised-coal feed to a solid-fuel turbine is provided by eight pressurised methyl-bromide suppressors in each of the feed hoppers, both of which are fitted with explosion detectors. Either detector fires all the suppressors.

Air removed from the top of the cyclone by an extractor fan by way of a long pipe-line carries over a certain amount of flour. To prevent the possibility of burning wood flour travelling down this pipe-line, an explosion detector and a 500 cc. suppressor are fitted at the top of the cyclone near to the air outlet. A high-rate discharge bottle is installed immediately after the rotary gate valve to prevent any smouldering wood flour from entering the hopper. A second high-rate discharge bottle protects the top outlet from the cyclone immediately before the extraction fan, which discharges any wood flour carried over into three small cyclones which in turn discharge on to a conveyor delivering the wood flour through a second rotary gate valve to the receiver hopper.

PROTECTION FOR PULVERISED-COAL FEED TO TURBINE

The largest and most intricate explosion-suppression system yet installed by the Graviner Company is in a pulverised-coal handling plant for an experimental solid-fuel turbine being developed by the English Electric Company, Limited, Rugby, for the Ministry of Fuel and Power. The plant, illustrated in Fig. 5, comprises an upper hopper of 104 gallons capacity and a lower hopper of 163 gallons capacity, delivering pulverised fuel to the turbine intake. The top hopper operates under pressures ranging between atmospheric and 60 lb. per square inch.

The cycle, which is repeated at approximately 15-minute intervals, commences with the opening of a valve at the top of the upper hopper, into which pulverised fuel feeds by gravity. When the

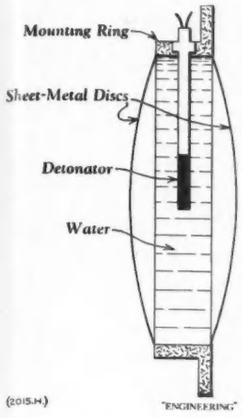


Fig. 6 Detonator-operated metal bursting disc for venting explosions.

hopper is nearly filled, the valve closes, and compressed air is introduced to raise the pressure. When it has attained 60 lb. per square inch, a valve in the bottom of the upper hopper opens and the fuel discharges to the lower hopper which operates continuously at 60 lb. per square inch; from this hopper the fuel is discharged through a rotary valve. The filling cycle in the top hopper is then repeated. Since the explosion pressure and the rate of rise of pressure are proportional to the normal pressure in the vessel, a final pressure of about 400 lb. per square inch might be attained in an uninhibited explosion. Each hopper is therefore protected by a detector and a ring of hemispherical suppressors – seven 500-cc. and one 100-cc. suppressors at the top of the upper hopper, and eight 1,000-cc. suppressors at the lower hopper. The two detectors are connected in parallel so that either actuates the whole system. To cope with the wide pressure and temperature variations – the latter may range from 0 deg. C. on starting up on a cold day to a working temperature of 50 deg. C. – the suppressors are pressurised to about 60 lb. per square inch, and more powerful detonators are employed.

EXPLOSION PROTECTION FOR ALTITUDE-TEST TANK

Another application is to a large suppression system which will shortly be installed at Vickers-Armstrongs Limited, Winchester, for the protection of an altitude-test tank for testing fuel systems under varying conditions of temperature and pressure. The pressure may vary between 2 lb. and 15 lb. per square inch absolute and the temperature from − 60 deg. to + 50 deg. C.

DETONATOR-OPERATED PRESSURE-RELIEF VENTS

Suppression cannot be applied to all industrial plant exposed to explosion hazard, since the pressure rise after suppression, plus the vapour pressure of the suppressing fluid, may amount to more than the plant can withstand — as, for example, in the case of a spray drier which may be designed to operate at a gauge pressure not exceeding 0·2 lb. per square inch. To protect such installations, the Graviner Company have developed detonator-operated venting systems, used in conjunction with the standard pressure-sensitive detector and power pack. Such systems can also be conveniently applied to outdoor installations where it is desired to protect the plant but where suppression is not essential.

Although the conventional pressure-operated bursting disc is satisfactory where it is required to burst at fairly high pressures, if the vessel is alternately subjected to vacuum and pressure it may be liable to early fatigue failure. When designed for low pressures, such discs tend to be very flimsy and to require frequent replacement if subject to even slight variations in pressure; moreover, their bursting characteristics are affected by temperature. The advantages of the Graviner detonator-operated bursting disc are as follows:—

(*a*) Relief panels of any required area can be opened at pressures as low as 0·1 lb. per square inch or rates of pressure rise as low as 5 lb. per square inch per second, or both. They are thus virtually the equivalent of an open vent.

(*b*) The pressure at which they burst is entirely independent of temperature.

(*c*) Since the triggering pressure is so low, the relief area can be smaller for a given vessel volume.

(*d*) The relief panels can be designed to withstand large fluctuating pressure loadings without fatigue and have, therefore, an indefinite life.

(*e*) The vessels or plant to be protected can be lighter in construction than would otherwise be possible.

For small plant, metal bursting discs up to 1 ft. in diameter can be incorporated at strategic points. As shown in Fig. 6, two discs are retained in a mounting ring and water is enclosed in the space between them. The shock from the detonator, which is housed in the ring, is transmitted through the liquid and bursts the metal discs. In large plants, substantial discs of armour-plate glass, clamped in a ring housing, as shown in Fig. 7, can be employed. The detonator is placed at the centre of the disc, about ¼ in. from the glass. When the detonator is fired, the disc breaks up into a characteristic pattern, as shown in Fig. 8, the action being complete in 2 to 3 milliseconds.

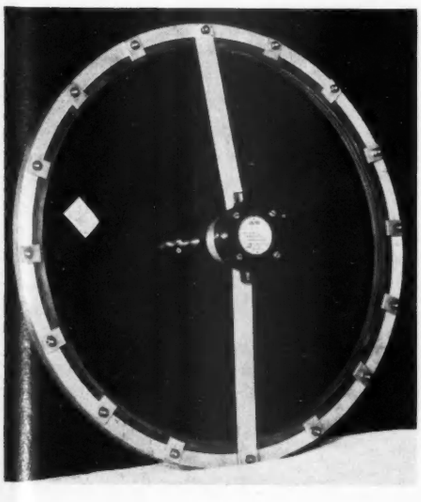


Fig. 7

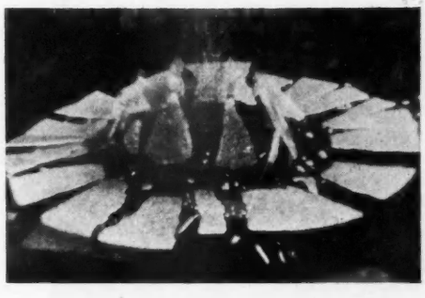


Fig. 8

The detonator at the centre of the armour-plate glass bursting disc causes it to fracture in the characteristic pattern shown in Fig. 8.

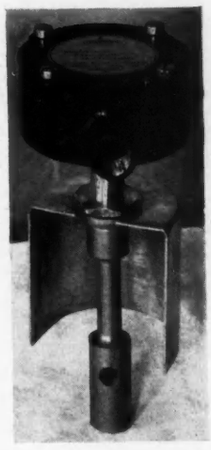


Fig. 9 Detonator-operated catch operating a mechanical linkage to release a venting panel.

A third system is the detonator-operated catch in which the detonator is used to operate a mechanical linkage for releasing spring-loaded or weighted venting panels. A typical example is illustrated in Fig. 9. The standard catch is designed to hold a load of one ton in tension.

COMBINED VENTING AND SUPPRESSION

In some plants a combined suppression and venting system may be used. Such an installation is in hand for a powder-drying plant where the drying chamber measures 12 ft. by 12 ft. by 24 ft. long. As the powder forms, the main part of it falls by gravity into an outlet duct at the bottom of the chamber, and is discharged through rotary gate valves. A residue of powder in the air is extracted primarily in a cyclone and finally by passing the air leaving the cyclone through a bag filter. The danger points in this plant are the valves, the cyclone, and the bag filter; detectors are therefore located at each of these points, and in the dryer chamber. In the chamber outlet duct is located a carbon-tetra chloride high-rate discharge bottle, firing downwards, to prevent flame from penetrating into the drier chamber and igniting the powder there. A high-rate discharge bottle is also installed in the inlet pipe to the cyclone, and a venting door at the top of the cyclone is actuated by a detonator-operated catch. The atmosphere in the drying chamber being damp, there is less risk of an explosion being initiated here, but protection for the chamber is provided by armour-plate glass bursting discs. Double discs, separated by an air space and sealed by rubber rings, minimise heat losses from the chamber. It is necessary to employ a separate detonator for each disc. All the detectors are connected in parallel, so that the whole suppression and venting system is actuated when any one of the detectors operates.

FUTURE DEVELOPMENTS

The use of photo-electric flame detectors is foreseen for certain limited applications where detection by the rate of rise of pressure is not practicable. Some work has already been done on the possibilities of photo-cells using Calor-gas as the explosive mixture, and it has been established that a type of barrier-layer cell gives sufficient output to operate a relay directly without amplification. By this method, detection at 0·1 lb. per square inch is practicable. Other types of rapid flame detector will shortly be available for use in vessels vented by large inlet and outlet ducts, including a modified resistance thermometer and a fusible sensing element, designed to respond within 50 milliseconds of the appearance of the flame.

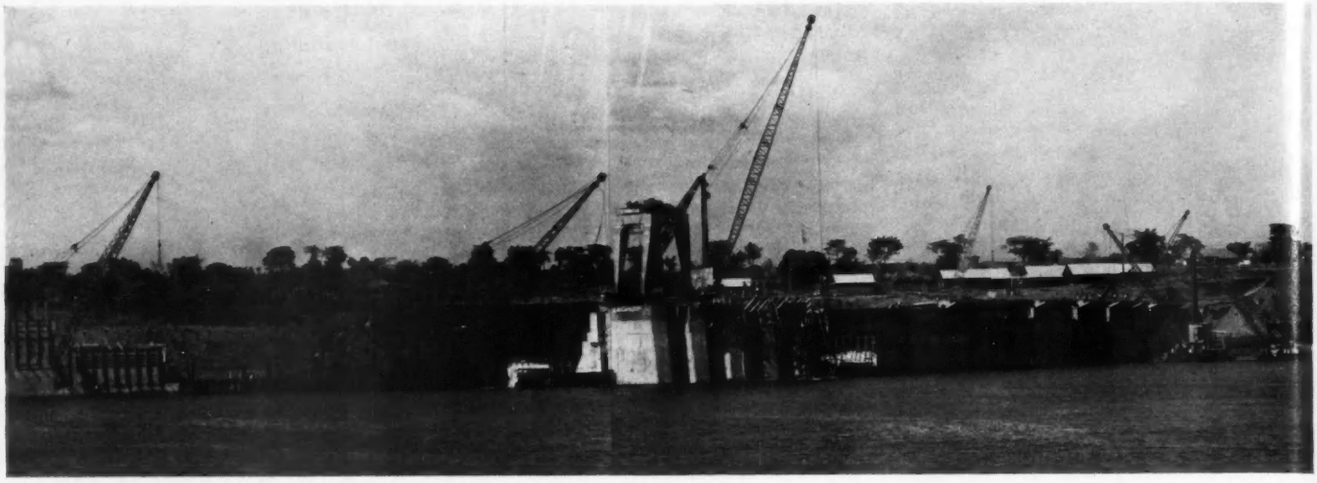


Fig. 1 Upstream side of 2,500-ft. gravity dam at Owen Falls, Uganda. Her Majesty the Queen is to visit the hydro-electric scheme on April 29.

Fig. 2 The main dam from the east bank of the Nile, showing the sluice dam which permits the flow of the river down to Egypt to be regulated.

Fig. 3 Temporary cofferdam at Ripon Falls being demolished by a dragline after it had served its purpose.

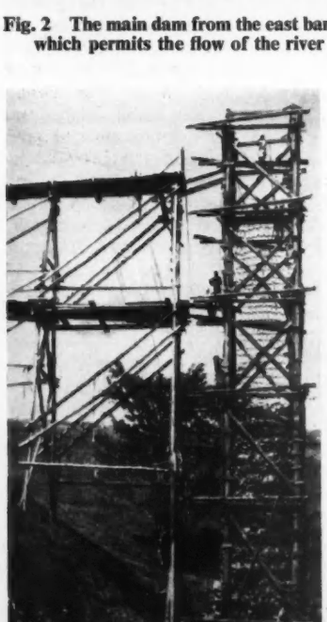


Fig. 4 Rock-filled gabion at Ripon Falls under construction.

Fig. 5 Eastern end of main dam at Owen Falls looking west from sluice dam.

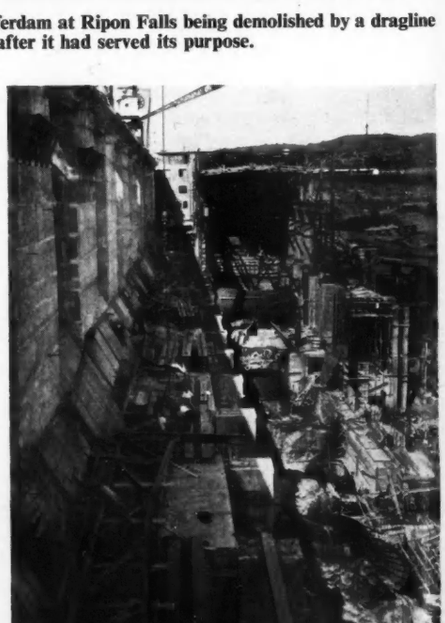


Fig. 6 Looking west to the intake dam and power house under construction.

THE OWEN FALLS HYDRO-ELECTRIC SCHEME

1—CIVIL ENGINEERING WORKS

THE Owen Falls hydro-electric scheme, which is to be formally opened on Thursday, April 29, by H.M. the Queen during her visit to Uganda, makes use of the water of the White Nile at a point about two miles below its source in Lake Victoria. This development has necessitated the construction of a dam across the river, as well as a power house which will ultimately contain ten 15-MW Kaplan turbines, six of which are to be installed at present. These sets, one of which is now in operation, are coupled to alternators generating three-phase current at 11 kV. The voltage is stepped up to 33 kV in an adjacent substation for transmission to the immediate neighbourhood. In addition, as shown on the map in Fig. 7, some of the output is stepped up to 66 kV for transmission to a station at Kampala, and to 132 kV so that it will be possible to give a supply westwards to Kampala and eastwards to Tororo. The last two lines will be the first to be erected in East Africa for operation at so high a voltage.

The scheme is potentially of great industrial importance, since Uganda is without coal resources and the import of furnace oil over 800 miles from the coast is expensive. Moreover, the existing sources of wood fuel are being rapidly exhausted, so that some means of obtaining cheap power is essential. The development should therefore not only meet the natural increase in the demand for power, but should be instrumental in attracting a number of important consumers.

Progress in this direction is, in fact, already taking place, since a cement works with a demand of some 3,000 kW has been established at Tororo, while a textile factory with an ultimate demand of 15,000 kW, 11,000 kW of which will be required for steam raising, is being built at Jinja. As regards the more distant future, the working of extensive deposits of copper at Kilembe 250 miles to the west of Owen Falls, and the deposits of iron ore, phosphate rock and columbium minerals 85 miles to the east, should provide a further potential demand, which would greatly exceed the ultimate installed capacity of the present station. In fact, the erection of a second station four miles further downstream is among the developments that may have to be considered in the near future.

HISTORY OF DEVELOPMENT

It may be recorded, as a matter of historical interest, that as long ago as 1907 Sir Winston Churchill wrote in his book *My African Journey* "it would be perfectly easy to harness the whole river and let the Nile begin its long and beneficient journey to the sea by leaping through a turbine."

Nevertheless, it was not until 1935 than an actual scheme for development was put forward jointly by two British firms of consulting engineers: Messrs. Preece, Cardew and Rider and Messrs. Coode, Wilson, Mitchell and Vaughan-Lee. This provided for the installation of some 90 MW of generating plant at Owen Falls, but was not proceeded with owing, apparently, to a doubt whether the demand for power would warrant its construction.

In 1947, however, the present chairman of the Uganda Electriciy Board (Mr. C. R. Westlake), reported that the time was favourable for development to take place. He advised that the necessary work should be put in hand without delay. A detailed engineering report was then prepared by Sir Alexander Gibb and Partners for the civil engineering work and by Messrs. Kennedy and Donkin for the electrical portion. This report, which was submitted to the Government in January, 1948, stated that a fully regulated discharge from the river could be secured with a storage range of only about 6 ft. 6 in. in Lake Victoria.

Shortly afterwards, construction was begun, the power station being planned to accommodate ten 15-MW Kaplan turbine units. Initially, however, orders for only four sets were placed; the first of which was started up on December 27, 1953. It is expected that the second will be running shortly, while the spiral casing of the third has been completed and its main components are on site. The size of the units has been limited by transport difficulties.

The civil engineering consultants are Sir Alexander Gibb and Partners, Queen Anne's Lodge, London, S.W.1, and the construction and installation of the electrical engineering equipment are being supervised by Messrs. Kennedy and Donkin, 12 Caxton-street, London, S.W.1. The chairman of the Uganda Electricity Board, who are controlling the development, is the Hon. C. R. Westlake, M.I.E.E., and the chief electrical engineer is Mr. J. M. Stock, M.I.E.E.

Before describing the engineering features of the scheme in detail something may be said about the hydrological conditions. The total catchment area of Lake Victoria, which is the third largest lake in the world and is the source of the White Nile, is 103,000 square miles. The average annual rainfall is 43 in., only 7 per cent. of which, however, flows into the river. The lake lies on a plateau about 3,700 ft. above sea level and its surface area is 26,000 square miles, or 34 per cent. of the land area which drains into it.

The average flow into the river is about 22,100 cusecs, with a maximum of 43,000 cusecs and a minimum of 10,500 cusecs. Records taken since 1896 have shown a variation of water level of only about 7 ft. At the request of the Egyptian Government the dam has been constructed to provide an additional storage of 55 million acre-feet for irrigation purposes.

As regards geological conditions, there are a succession of falls and rapids between the outlet of the river from Lake Victoria and the site of the new dam. These are caused by bars of hard amphibolite rock, which project across the bed at intervals and are strongly resistant to erosion. The intervening material is of a softer and more erodible nature and is similar to shales. The rock is traversed by joint planes to variable depths and some difficulty was therefore experienced in obtaining large plums for the cyclopean concrete in the dams. As described in detail below, the rock has been used as aggregate for all the constructional concrete.

DESIGN OF THE MAIN DAM

The principal civil engineering work in connection with the development is a mass-concrete gravity dam, 2,500 ft. long and 100 ft. high, which has been built across the river. It is shown at different stages of construction in Figs. 1 and 2, on the opposite page, as well as in Figs. 5 and 9. The height is 3 ft. more than is necessary for power requirements, but, as already mentioned, it will enable more water to be released for irrigation purposes in Egypt during periods of drought. The contractors for this work were the Owen Falls Construction Company, and, as will be seen from Fig. 10, the dam and road-works are

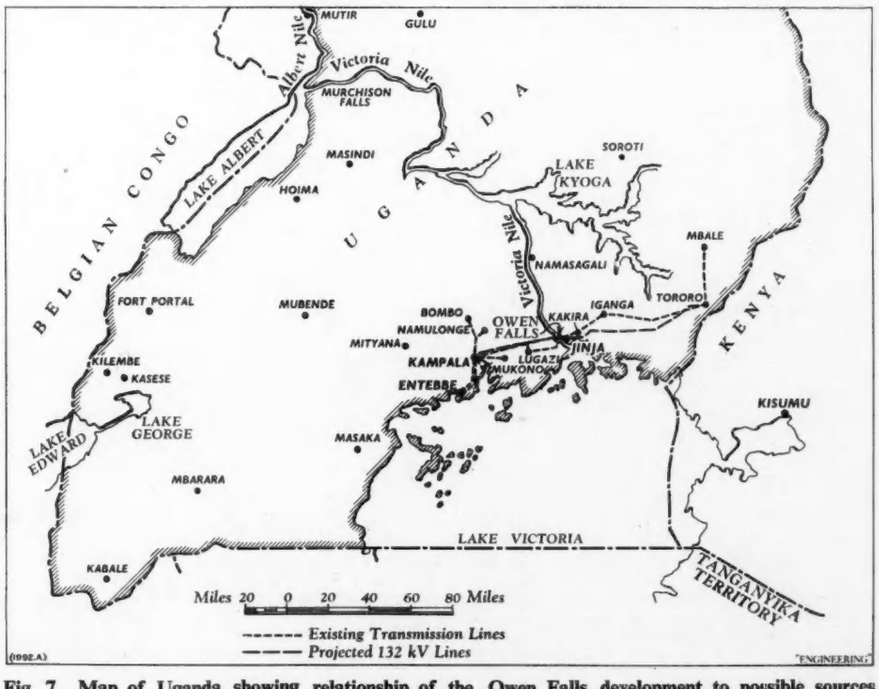


Fig. 7 Map of Uganda showing relationship of the Owen Falls development to possible sources of load.

Fig. 8 An early view of the work illustrating a cofferdam and sheet steel piling used for the construction of the main dam.

roughly S-shaped in plan, with a radius of 745 ft. against the pressure of the water. The dam is made up of two main sections extending outwards from the west and east banks of the river, respectively. The western portion terminates in a road bridge, which crosses the entrance to the power station headrace; and the eastern portion in a sluice dam. The latter dam is connected to a third short length of main dam, to which the other end of the bridge gives access. A typical section through the main dam is given in Fig. 12.

The sluice dam contains six ground sluices, each 16 ft. 9 in. high and 9 ft. 10 in. wide. These sluices are designed to pass the maximum flow of the river, or about 45,000 cusecs, regulation being effected by free-roller dry-well control gates. The gates, which were manufactured by Glenfield and Kennedy, Limited, Kilmarnock, are of mild steel with self-adjusting rubber seals and run in Meehanite reception frames, the guides of which are provided with seating faces of Naval brass. They are electrically operated through worm and spur gearing and twin Renold chains, their movement being controlled either locally or from the power station. They are designed to sustain and operate against an unbalanced head of 76 ft. at the sill. Free-rolling emergency gates, manufactured by the same firm, are installed upstream of each main gate and can be raised or lowered by a 50-ton electrically-operated Goliath crane, supplied by Sir William Arrol and Company, Limited, Glasgow.

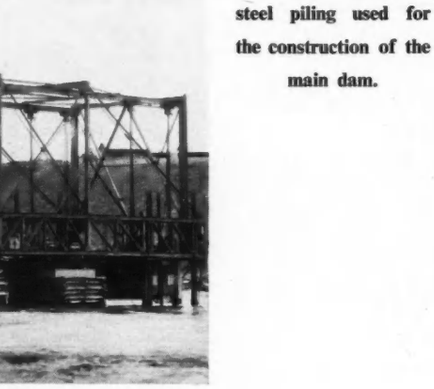


Fig. 9 One of the sections of the main dam under construction as seen from a corner of the east headrace dam.

At the outlets of these sluices are concrete buckets with a slope of 3 deg. to dissipate the energy of the water and to eliminate scour along the back of the dam. To determine the best position for these sluices in relation to the river channel, to ascertain the damping effect of the buckets and to calibrate the flow, experiments were carried out on a model by Professor C. M. White at the Imperial College, London. The contractors subsequently took advantage of some of the facilities provided by this model to determine the water levels at various river flows with different designs of cofferdam. Some indication of the volume of water that has to be dealt with is given in Fig. 13.

As will also be seen from Fig. 10, the power station is built on a low promontory, which juts out into the main channel downstream of the dam. The headrace, which is 200 ft. long, has been excavated through this promontory and, as has already been said, is crossed by a bridge. The roadway over this bridge continues along the top of the dam on to the shore and will replace a road which lay about a mile upstream.

FLOW REGULATION

The most difficult problem in the construction of the dam, which was begun early in 1950, was to regulate the river flow so that the bed could be de-watered. The solution adopted was to construct a temporary rock-fill dam across Ripon Falls, at the outlet from Lake Victoria, to build a sluice regulator across the right-hand channel of the river at this point and to restrict the flow in the left channel by a rock-filled gabion. The temporary dam is illustrated in Fig. 3, while the gabion is shown in Fig. 4. The gabion consisted of a timber tower 90 ft. high, which was filled with 400 tons of rock and felled into the channel. The river flow was thus restricted to a maximum of 21,000 cusecs by making use of the storage capacity of the lake. The cofferdams employed in the construction of the main dam were designed for a flow of 28,000 cusecs to provide some margin. This barrier at Ripon Falls will be removed when the scheme is completed to enable sufficient water to be passed for operating the turbines when the lake level is low.

MAIN COFFERDAMS

The constructional works erected on the site of the main dam were in three parts. Starting from the left bank, a murrum cofferdam was formed as far as a small island about one-fifth of the way across the river, and the bed was then de-watered and excavation began in December, 1950. Crib cofferdams were next constructed to a point almost half-way across the remaining channel and enclosed the position to be occupied by the ground sluices. The remainder of the work was carried out after the river had been diverted through temporary openings in the foundations of the main dam.

The cribs which formed the cofferdams in the deep, fast-flowing water, consisted of Kenya blue-gum logs, which were bolted together in three sections not exceeding 45 tons in weight to facilitate placing. The bottom section was shaped to fit closely to the configuration of the rock barrier. These cribs were placed at 30-ft. centres by a travelling gantry and were connected by steel beams which supported a line of steel sheet piles on their faces. The bottoms of these piles rested on the hard amphibolite rock, against which they were sealed by clay and

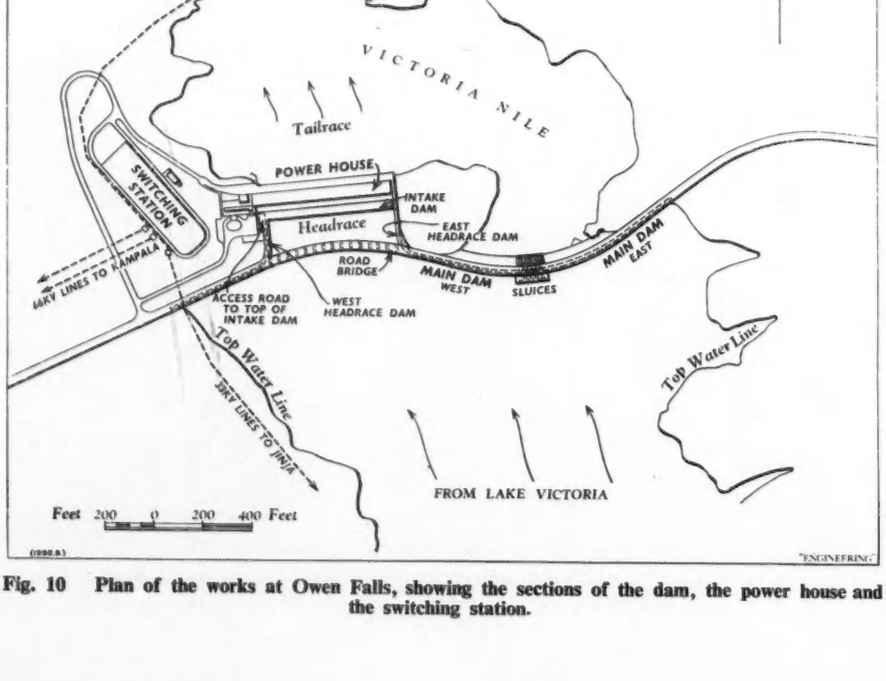


Fig. 10 Plan of the works at Owen Falls, showing the sections of the dam, the power house and the switching station.

murrum, although where deep fissures and gravel pockets were encountered other methods were adopted. The gantry was used initially to ascertain the exact configuration of the rock by plumbing with steel struts, normal methods of sounding not being sufficiently accurate owing to the volume and velocity of the water. When the levels of the bed had thus been accurately found the bottom section of each crib was made to its exact dimensions, transported to the traveller and lowered to water level where it was held in position while a second section of the crib was bolted to it. The two sections were then lowered into position and the crib was filled with rock. Finally, a third section was bolted on and finished with a concrete slab to take the traveller track. Smaller cribs were similarly placed on the downstream side to seal the ends of the cofferdam. One such cofferdam, with its sheet-steel piling, used in the construction of the main dam is illustrated in Fig. 8.

The dams forming the sides of the headrace and the intake dam, the positions of which are shown in Fig. 10, were constructed in the dry on the rocky spur which juts out from the left bank of the river. Any encroachment of water was prevented by the cofferdam for the power station. Views of the intake dam and power-house building are given in Figs. 6 and 11.

Fig. 11 View of the intake dam and power-house building looking south-east.

CONCRETE PLANT AND METHODS

The rock required for making the 223,000 cub. yd. of concrete used in constructing the dam was crushed and screened on site by plant erected by Pegson Limited, Coalville, Leicestershire. The rock forming the raw material was of close-grained igneous structure with a small proportion of river-bed gravel; it tended to "slabbiness" when crushed, owing to its inherent parallel lines of cleavage. The plant was designed to deal with 125 tons of coarse aggregate of all sizes per hour as well as with 60 tons of sand per hour. The sizes of the aggregate required were 3 in., 1½ in., ¾ in., ⅜ in. and $\frac{7}{16}$ in. (sand). Additional natural sand was dealt with separately as mentioned below.

The quarried stone was extracted by 1½ cubic yard shovels and loaded into 4½ cubic yard dumpers, which delivered their contents either into a gyratory crusher or into skips. A feeder was unnecessary since the crusher was capable of dealing with any stone that could be picked up by the shovels. This crusher had a reserve capacity of 350 tons per hour so that it could deal with fluctuating supplies, and was erected at a considerable height above the ground, so that a minor "surge" pile of crushed stone was established inside the foundation walls under the primary stage.

Stone of sizes less than 8 in. was extracted from this pile by two Sherwin magnetic feeders and conveyed to two gyratory crushers, in one or both of which secondary crushing could be carried out. Provision was made for any "muck" present in the crushed stone to be extracted and delivered to ground level through chutes.

Alternatively, each of these machines could be fed direct from its own storage hopper, which was filled by the dumpers as required and the outlet from which was controlled by hanging chains. This arrangement allowed the larger crusher to be shut down when the fragmentation obtained by blasting was particularly good. The minus 4½ in. stone from these machines was delivered through chutes to a troughed belt conveyor, which was 30 in. wide and ran at 200 ft. per minute. This conveyor which, like others on the plant, was constructed by Hugh Wood and Company, Limited, Gateshead-on-Tyne, and had a capacity of 220 tons of crushed amphibolite per hour, was also supplied with river-bed gravel from a receiving hopper and an electric vibrating feeder at a controlled rate. The gravel added in this way was equal to about 10 per cent. of the crushed rock.

SCREENING

The stone and gravel were taken by this conveyor to a structure containing screens and storage bins. The first and upper screen forming this part of the plant was of the triple-deck inclined vibrating type and was 12 ft. long by 5 ft. wide. All stone larger than 3 in. was rejected by this screen down a chute and along a conveyor into a 20-ton hopper for re-crushing, while the smaller sizes were passed through a second double-deck screen into a five-compartment surge hopper. The larger rejects were extracted from the bin and broken up in two swing-hammer crushers, the output from which was transferred by a 24-in. troughed belt conveyor to the main conveyor mentioned above and thence, once more, to the screening plant.

Additional quantities of aggregate of less than ¾ in. were, when required, obtained by drawing 3 in. to ¾ in. material from the appropriate bins by magnetic feeders and delivering it by a 24-in. troughed belt conveyor to a 48-in. Gyrosphere fine crusher. This machine was capable of reducing the minus 3½ in. stone to minus ¾ in. at the rate of 45 tons per hour; and its output was deposited on the 24-in. troughed belt conveyor mentioned above, along with that from the two swing-hammer crushers. It was then re-screened, thus increasing the quantity of small-size aggregate available. Collectors were installed at places where the greatest quantities of stone dust were produced, the resulting laden air being extracted by 7-ft. cyclones.

STORAGE ARRANGEMENTS

The different grades of aggregate were stored in six major stock piles, the total capacity of which was 14,000 tons. These piles were formed by the loads of five separate inclined trough conveyors, each of which was 18 in. wide and ran at a speed of 150 ft. per minute, their capacity varying from 25 to 55 tons per hour. The delivery end of each of these conveyors was cantilevered out from its supporting tower, so as to leave the base of the stockpile clear of obstruction and to give easy access for bull-dozers. The aggregate was withdrawn from each pile through three chutes with quadrant valves and swivel size plates and delivered to two 26-in. troughed belt conveyors with a capacity of 200 tons per hour. These conveyors, which were installed in timber tunnels, delivered their loads on to a 285-ft. inclined trough belt conveyor, which discharged them into the hoppers of the batching plant at a height of 81 ft.

CONCRETE BATCHING PLANT

The concrete batching plant, supplied by Winget Limited, Rochester, consisted of a 200-cub. yard bin with six aggregate compartments and a central cement compartment with a capacity of 30 tons. The bin and operating

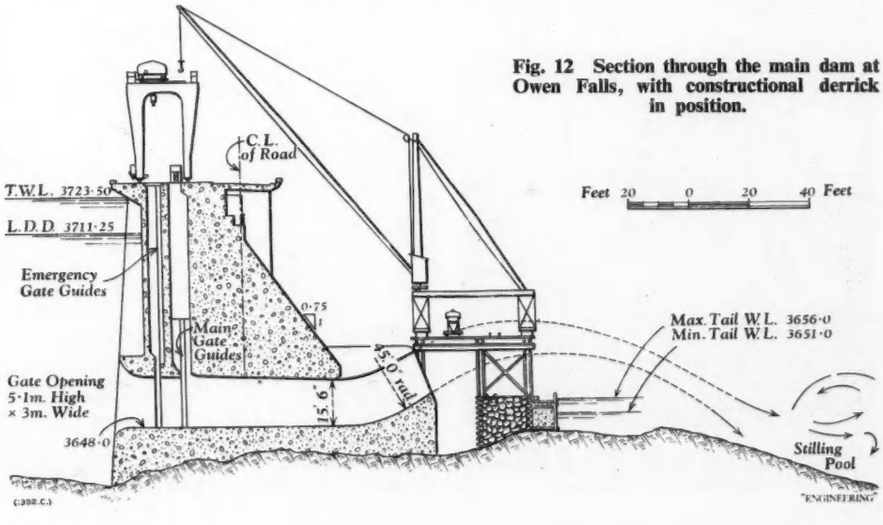


Fig. 12 Section through the main dam at Owen Falls, with constructional derrick in position.

platform were supported by steel stanchions down to mixer base level and then on a reinforced concrete substructure to reduce the vibration from the mixers. Below the bin were eight batchers of the single-material fully-automatic type, one of which was used for cement and one for water, while two others were employed for sand and four for the coarse aggregates. The sand, cement and water batchers were provided with four, and those for the coarse aggregates with three, beam scale units. In every case the beam operation was effected by a small air cylinder and lifter, which, in turn, was controlled by solenoid-operated valves energised by switches on the control panel, so that the various mixes could be pre-selected.

The filling of the weigh batchers for the sand and coarse aggregates was controlled by radial non-jamming valves operated by air rams. The rams were also controlled by solenoid-operated valves, which were energised through two switches operated by the appropriate beams. Directly the fill valves were opened the gate moved through its regulated travel and the main switch on the appropriate beam was opened, thus closing the gate. The second switch next came into operation and caused the filling valve to oscillate, so as to control the final topping up of the material to the correct weight. Both solenoids were then de-energised and the fill valve closed. Each beam scale equipment was fitted with an overload switch which showed by a lamp on the control panel whether the pre-selected load had been exceeded and rendered the discharge timer inoperative until the error had been corrected.

When the batchers had been charged their contents were delivered into the mixers through gates which were opened in the correct sequence by a timer operated by a push button on the control panel. The batched material therefore entered the drums in the right order so that jamming in the collecting cone or charging chute was prevented. The switches on the control panel enabled each batch to be individually or collectively controlled and either automatic or manual operation instituted. It also enabled the two-way chute and the tilting of the mixers to be regulated from the control panel. Each mixer was provided with a batch meter, which ensured its discharge into a wet hopper and thence into one or other of two lines of buckets which were taken by a derrick to the site of the dam.

The natural sand required for concrete manufacture was obtained from a beach on Lake Victoria and shipped to Jinja by barge. It was there unloaded by grab crane into lorries for transport to the site and dumped into a water-filled concrete hopper. A solution of 30 per cent. sand and 70 per cent. water was pumped from this tank into a cone, which delivered 40 cub. yards per hour of washed sand graded to $\frac{1}{8}$ in. on to a stock pile above one of the tunnel conveyors mentioned earlier. After being weighed it was fed into the concrete mixers. This part of the equipment was manufactured by William Mosley (Engineers), Limited, Feltham, Middlesex.

Fig. 13 Downstream side of the sluice dam, showing the discharge.

CEMENT MANUFACTURE

Initially, the local limestone was not considered suitable for the manufacture of cement, since it had a phosphate content of up to 2 per cent. and resulted in a weak and badly setting material. Of the 50,000 tons required, 60 per cent. was therefore shipped in sacks from this country to Mombasa and brought up by rail to the site, where it was emptied into hoppers and withdrawn thence by a screw and bucket conveyor into a central bin. At a later date, however, following investigations at the British Building Research Station, the difficulty of the presence of phosphates was overcome, and works with an annual output of 60,000 tons were opened by the Uganda Cement Industry. The consulting engineer for the erection of the plant in this factory was Mr. Henry Pooley. During the later stages of construction the output of this factory was delivered in wagons to the site and discharged by a horizontal screw and elevator into a 640-ton storage bin.

It may be added that a second process which has been developed at the Building Research Station enables the phosphate to be entirely removed from the limestone and used as a fertiliser.

All the crushers, screens and conveyors were independently driven by totally-enclosed surface-cooled electric motors with tropical windings. Those for the three crushing stages were controlled from an elevated cabin commanding a direct view of the plant, and those for the screens and conveyors from a point at the top of the main screening section. Sequence starting was installed, while emergency push buttons for stopping were provided at all essential points. A 10-ton 120-ft. derrick crane was erected to deal with the heavy constructional lifts and for servicing. Owing to the remoteness of the site and the limited skilled labour available, the equipment was designed so as to minimise the risk of breakdowns. In particular, the bearings were capable of withstanding the high temperatures and all high-load bearings were automatically lubricated.

Power for driving the constructional equipment and for the labour camps was provided from the Uganda Electricity Board's system.

CONSTRUCTIONAL PROBLEMS

The main gravity dam was constructed in sections between which openings 15 ft. wide were left at 30-ft. centres to allow for the contraction of the concrete on cooling and to provide temporary passages for the flow of the Nile.

As already stated, work was begun in December, 1950, and during 1951 and the following year good progress was made in the construction and placing of the cribs for the first main cofferdam. By the end of 1952 twelve of the main upstream cribs had been completed, as well as the smaller downstream cribs for the second cofferdam. The cribs and sheet piling for the second cofferdam of the main dam were also completed. Difficulties were experienced in sealing this cofferdam owing to the discovery of a pocket of gravel in the south-east corner. The underwater rock was also found to be fissured, pitted and broken, with the result that de-watering and the concreting for the sluice dam were delayed. Good progress was nevertheless made with the concreting of the main dam east of the headrace.

Excavation on the east bank of the river was begun in July, 1952, and a suitable foundation level was reached in October. In order that the dams in the east bank could be concreted before the main upstream cribs had been completed a temporary gantry was built downstream to bridge the remaining gap.

The main dam west of the headrace and the west headrace dam itself were also completed during 1952, with the exception of filling the contraction gaps and the extreme western cut-off.

The concreting of the roadway over the west headrace dam was begun during the year and had been more than half completed at the end of that period.

The last cofferdam for the main dam was de-watered in June, 1953, and by the end of that year all the cofferdams had been removed, except those round sets 4 to 10 in the power house where construction work below river level is still in progress. The main dam west of the headrace and the intake and headrace dams had also been completed.

The second and final article will describe the turbines and electrical equipment that are being installed at Owen Falls. A note on the Owen Falls scheme appears in Weekly Survey in this issue.

* * *

EFFICIENCY OF MAIN DRAINAGE SYSTEMS

L.C.C. to Undertake General Examination

The last major investigation into London main drainage began just before the 1914 war, and a report which recommended a number of large improvements, principally for the relief of flooding, was approved in 1919.

In the 35 years since that date, there has been considerable change in the conditions affecting both the soil and surface-water drainage of London, and in order that the sewerage side of the London main drainage system shall be maintained in an efficient state, a further general examination of the whole system is to be undertaken.

The Rivers and Drainage Committee of the London County Council have authorised this investigation to begin as soon as possible. It will be a considerable time before a comprehensive report can become available as many factors affecting the hydraulics and capacity of the system are involved.

* * *

SEA DEFENCES

Wave Research Congress

From 1950 onwards, the Council on Wave Research of the Engineering Foundation at the University of California has organised a series of annual conferences in the United States on problems relating to the study of waves. The fifth conference will be held at Grenoble, France, from September 8 to September 11, 1954.

Subjects to be dealt with will include the creation and movement of waves, the transport of materials in suspension, coast formations, and the planning and construction of sea defences.

The committee invite the submission of papers on subjects covered by the conference. These may be in English or French, should not exceed 12,000 words in length, and must reach the committee not later than June 30. Communications should be addressed to the Coastal Engineering Congress, Ecole Nationale Supérieure d'Electrotechnique et d'Hydraulique, 44-46 Avenue Félix Viallet, Grenoble, France.

WATER-POWER RESOURCES OF CANADA

ONE HORSE-POWER PER PERSON

The Water Resources Division of the Department of Northern Affairs and National Resources, Canada, has issued its annual review of the potentially available and already developed water-power resources of Canada. The review summarises the latest available information regarding the water-power resources and developments in each province, and gives a brief survey of the distribution by provinces, the utilisation and the relationships between the power made available and the population.

The recorded water-power resources of Canada are now shown to total more than 29 million horse-power under conditions of low stream-flow and nearly 51 million horse-power under average-flow conditions. This represents a possible installed capacity of 66 million horse-power of which but 23 per cent. has so far been taken up.

TOTAL AND DEVELOPED WATER POWER

Reproduced below is a table showing the total water-power resources of Canada and the present total capacities of all water-power plants in the Dominion as at the end of 1953.

Province or Territory	Available Continuous Horse-Power at 80 per cent. Efficiency		Horse-Power Installed. Turbine Capacity
	At Ordinary Minimum Flow	At Ordinary Six-Months' Flow	
1	2	3	4
British Columbia	7,023,000	10,998,000	1,496,518
Yukon and N.W.T.	382,500	814,000	32,440
Alberta	508,000	1,258,000	207,960
Saskatchewan	550,000	1,120,000	109,835
Manitoba	3,333,000	5,562,000	716,900
Ontario	5,407,000	7,261,000	4,006,686
Quebec	10,896,000	20,445,000	7,719,122
New Brunswick	123,000	334,000	164,130
Nova Scotia	25,500	156,000	162,433
Prince Edward Island	500	3,000	1,900
Newfoundland	958,500	2,754,000	311,150
Canada	29,207,000	50,705,000	14,929,074

In the above table, the figures of columns 2 and 3 have been calculated on the basis of continuous output at an efficiency of 80 per cent. The figures of column 2 are those of the continuous power estimated to be available on the basis of the average of the mean flows of the two lowest periods of seven consecutive days in each year within the period covered by record; the figures of column 3 are based on the computed dependable stream-flows usually available for at least six months in a year under existing flow conditions.

The above figures are, therefore, conservative and are stated to represent the minimum water-power possibilities of Canada. Moreover, they do not include many power sites, for which record does not yet exist, situated particularly in the less-explored northern districts.

The growth of water-power development has been rapid and continuous since the beginning of the century when the total installed capacity was 177,000 h.p., an insignificant figure when compared with the present-day total of almost 15 million horse-power. Between 1900 and 1905 installation was at the rate of 56,000 h.p. a year, but during the last five years the average annual increase in installed capacity was 740,000 h.p. a year.

At the present time, 90 per cent. of the total installed capacity of 14,929,074 h.p. is in central hydro-electric stations, 6·2 per cent. is exclusively for the use of pulp-and-paper mills and 3·8 per cent. is exclusively for the use of other industries. During 1953 a total of 61,608 million kWh was generated from water-power in the central stations, an increase of approximately 5 per cent. on the figure for 1952. A total installed new capacity of 638,000 h.p. was brought into use during the year and present programmes indicate similar increases will annually be made for some years.

The figures of installed water power per thousand of the population vary from 1,808 h.p. in the case of Quebec to 18 h.p. for Prince Edward Island, the average for the whole country being 1,010 h.p., or almost exactly 1 h.p. *per capitta.*

PRODUCTION OF METALLURGICAL COKE

COKING COALS CONSERVED BY BLENDING WITH LOW-RANK OR GAS COALS

The hard coke required for metallurgical purposes has always been made either from Type 301* coking coal of 20 to 30 per cent. volatile matter which occurs only in Durham and South Wales, or from gas-coking or gas coals (types 400, 500 or 600). Type 301 coal gives the best-quality coke, little difficulty being experienced in producing coke having a 1½ in. shatter index of 80 to 90; values of 90 or over are often attained. Although the cokes produced from the other coals, particularly types 500 and 600, are not of such high quality, they are still acceptable for blast-furnace use. With the growth of the steel industry, demands for metallurgical coke are increasing and supplies of suitable coal are inadequate. In particular, the reserves of the best coking coals are low, amounting to only 6 per cent. of the total coal reserves of the United Kingdom, the best seams are approaching exhaustion, and mining costs are relatively high.

For several years the Fuel Research Station of the Department of Scientific and Industrial Research has been investigating the possibility of eking out these valuable coals and producing hard coke by carbonising blends with other more plentiful coals. At a meeting of the Institute of Fuel, held in London on February 23, Mr. H. Bardgett, of the Fuel Research Station, described the success that has already been achieved and gave details of the results.

He stated that carbonisation had been effected in a setting of two Woodall-Duckham intermittent vertical chambers, each holding a charge of 2¼ tons. This procedure had been decided upon after experiments in collaboration with the National Coal Board had confirmed that the cokes produced from coking and gas coals in these chambers were similar in physical properties to cokes made from the same coals in commercial coke ovens.

The experiments had shown, in general, that a weakly-caking high-volatile Northumberland coal could be blended with Durham coking coal, gas-coking and gas-making coal, of types 301, 401 and 501, to the extent of up to 60 per cent. for producing coke of 2-1½ in. shatter indices of 80 to 90, and up to 50, 30 to 40, and 40 per cent., respectively, without reducing the Cochrane abrasion index below the generally accepted limiting value of 74. The shatter strength of such coke was appreciably better than that of a high proportion o fcoke produced and used in this country for metallurgical purposes.

The replacement in this way, by Northumberland low-rank coal, of 40 per cent. of the 7½ million tons of Durham coal used per annum for coking, would represent a saving, allowing for additional coal to offset a 12 per cent. reduction of coke output, of up to 2½ million tons of good coking coal a year.

Experiments had also shown that Durham gas coal, type 501, could be blended in any proportion with Durham coals of types 301 and 401 and produce coke of 1½-in. shatter index of 90 or over.

Durham low-volatile " cinder " coal that had been affected by igneous intrusion, and appreciable reserves of which existed, could be utilised in the production of metallurgical coke. Blended with Durham type 401 coal to the extent of from 20 to 25 per cent. it had little effect on the coke strength and yield, and the proportion of large coke produced was appreciably increased.

* " Rapid Survey of Coal Reserves and Production," *Fuel Research Survey Paper No.* 58. (H.M. Stationery Office, London, 1946.)

* * *

GASIFICATION OF COAL

Liége International Conference

Further information is now available respecting the International Conference on the Complete Gasification of Mined Coal, to be held at Liége from Monday, May 3, to Saturday, May 8.

Morning and afternoon sessions on May 3, 4 and 5 will be devoted to the consideration of technical papers and reports. At the morning session on the first day, general reports will be presented on the oxygen gasification of solid fuels on the American continent, coal gasification in producers and water-gas generators, completely-mechanised coal-gas producers, and the caking of bituminous coals during complete gasification. Theoretical and laboratory reports on the hydrogenation of coal, the gasification of carbon, fixed-bed gasification, and the calculation of gasification processes in suspension will be considered in the afternoon.

Tuesday will be devoted to papers on fixed-bed gasification processes. Subjects to be dealt with will include the gasification of high-ash fuels, the complete gasification of bituminous coals, plant at Rome gasworks, and the gasification of coals in cupola and low-shaft furnaces.

Papers on gasification processes in fluidised beds and in suspension will be discussed at the morning session on Wednesday. The subjects for consideration will include the Panindco process, the Koppers-Totzek process for the gasification of pulverised coal, and the production of water gas in fluidised beds. Economic and miscellaneous reports will be presented at the final session, on Wednesday afternoon.

The organisers of the conference are the Institut National de l'Industrie Charbonnière (Inichar), 7 Boulevard Frère Orban, Liége, Belgium.

SWITCHGEAR AT NECHELLS "B" POWER STATION

COMBINATION OF STONEWORK AND METALCLAD UNITS

The Nechells "B" power station in the Midlands Division of the British Electricity Authority is now approaching completion and will have a total capacity of 210 MW. The steam raising plant will consist of 12 stoker-fired boilers, manufactured by International Combustion, Limited, Woburn-place, London, W.C.1, with a combined output of 2,760,000 lb. of steam per hour at a pressure of 675 lb. per sq. in. and a temperature of 850 deg. F. These boilers will supply four Parsons turbines, each of which will be directly coupled to a 50-MW main and a 2·5-MW house-service alternator. The main sets will generate at 11 kV and the output of the first two, which were commissioned in 1951, is controlled by switchgear of the stonework cubicle type, which was supplied by the General Electric Company, Limited, Kingsway, London, W.C.2, to the Nechells "A" station over 27 years ago. The other two sets are to be controlled by metalclad switchgear of modern design, which was made by the same firm.

1,000-MVA METALCLAD EQUIPMENT

The new 11-kV metalclad equipment consists of 14 totally-enclosed units, each with a rupturing capacity of 1,000 MVA. The switchgear, a portion of which is illustrated in Fig. 1, is divided into three sections by brick walls and a further wall segregates the equipment itself from the main and control cables. A duplicate bus-bar system, which is designed for a continuous rating of 4,000 amperes, is installed and is electrically divided into two sections, to each of which a generator is connected and from which the grid transformers and group feeders are supplied.

A typical 4,000-ampere circuit-breaker is illustrated in Fig. 2. It is of double-break construction and is arranged for vertical isolation by means of an electric hoist operated from the front gangway. This hoist is also used to lower the tank of the circuit-breaker to give access to the contacts and the arc-control pots. The moving arc contacts are cylindrical in section and are tipped with heavy alloy to ensure a high resistance to burning; they engage with finger-type fixed contacts, which are mounted in side-blast arc-control pots. The wedge and finger main contacts give a high-pressure contact and a self-cleaning contact surface.

The isolating contacts consist of groups of self-aligning plugs with slotted spherical ends, which are mounted on the tops of the bushings that form the terminals of the circuit-breaker. They make contact with sockets drilled into contact blocks which are supported by the bus-bar and spout insulators. The sockets are protected by automatic shutters when the circuit-breaker is lowered.

BUS-BAR SELECTION

Bus-bar selection is effected by on-load isolators' which are normally motor-operated but can also be opened and closed by hand. Furthermore, the on-load feature can be dispensed with, and the isolators operated, either electrically or manually, under off-load conditions. The oil-insulated selectors are contained in the fixed part of the unit between the bus-bar chambers, and are so arranged that the connections from the duplicate bus-bars do not meet in a common chamber. The switchgear is phase-separated throughout and, owing to the high current rating, an extremely heavy construction is employed. The circuit-breakers are withdrawn from the front gangway, and the voltage transformers from a central gangway which can also be used to give access to the rear of the breakers.

The voltage transformers are completely segregated from the circuit-breakers, and are arranged for vertical isolation by means of a hoist operated by hand from the centre gangway. The ceiling of this gangway can be removed in sections to give access to the secondaries of the current transformers. A catwalk immediately above the voltage transformers gives full access to the current transformers and also affords access to the boxes housing the auxiliary terminals and fuses. The solenoid contactors, auxiliary switches and other ancillary apparatus are mounted in a large panel at the front of the unit; the controls for local operation are in a pocket below this panel.

The bus-bars are of the condenser-bushing type, and the T-off connections to the selector isolators are enclosed in single phase, compound-filled chambers constructed almost entirely from non-magnetic steel. The current-transformer primaries are also condenser bushings, and ample space is provided for accommodating the secondaries. The isolation spouts for the circuit-breakers are formed in the lower portion of the selector chambers and the feeder connection chambers.

MINIMISING TEMPERATURE RISE

In the construction of this switchgear, special efforts have been made to minimise the temperature rise. The copper conductors have been designed to limit heating and to give good heat dissipation. Much non-magnetic material has been incorporated in the structure, and all the contact surfaces are heavily silver-plated. Natural ventilation of the unit is provided by means of louvres in the enclosing covers. A heat run carried out on this switchboard at 4,000 amperes over a continuous period of 40 hours showed that the maximum temperature rise at any point did not exceed 26 deg. C. The equipment was also subjected to short-circuit tests at the full rating, including proving of the earthing attachments.

11-KV GROUP SWITCHGEAR

The 11-kV group switchgear is also of the duplicate bus-bar metalclad type, and has a rupturing capacity of 250 MVA. It consists of 27 units which are arranged as two switchboards with a cable interconnection.

The oil circuit-breakers in this switchgear are of the double-break type and are fitted with self-generating side-blast arc-control pots. Each breaker is mounted, together with its closing mechanism, on a carriage which can be completely withdrawn from the unit for inspection and maintenance. Bus-bar selection is achieved by lowering the circuit-breaker and moving its carriage backwards or forwards into registered positions. The circuit-breaker, which is raised into the service position by a manually-operated hoist, is fitted with isolating contacts similar to those on the 1,000 MVA switchgear. The bus-bars are of rectangular section and are arranged in triangular formation in a compound-filled chamber.

The solenoid contactor and ancillary apparatus are housed in a compartment at the front of the unit. This compartment is fitted with a door on which the controls for local operation are mounted. Ring-type current transformers are mounted in a compartment situated above the rear bus-bar chamber, and the voltage transformer is mounted on the top of the unit towards the rear of this chamber. The voltage transformer is contained in a steel tank which is mounted on rollers, and is arranged for horizontal isolation.

MODERNISATION OF ORIGINAL SWITCHGEAR

The stonework cubicle switchgear installed in the original Nechells "B" station was designed to control four 22·5-MVA, 5·5-kV, 25-cycle turbo-alternators and a total of 32 feeder circuits. The alternator and bus section circuit-breakers were rated at 4,000 amperes and those on the trunk and group feeders at 2,000 amperes. Moving contacts of wedge section, which engaged with copper-tipped fingers, were employed, and each circuit-breaker, together with its isolating links and instrument transformers, was installed in a stonework cubicle with steel plate doors at the front and rear.

During the frequency changeover period in the

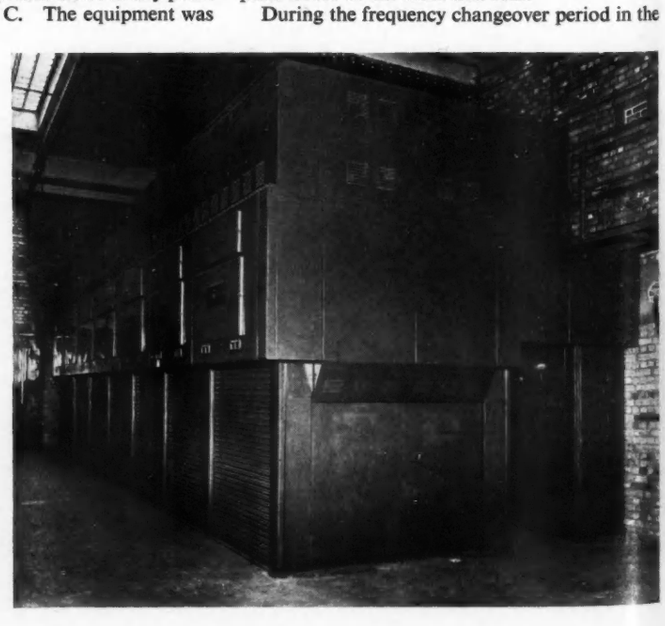


Fig. 1 1,000-MVA, 11-kV metalclad switchgear in Nechells "B" power station.

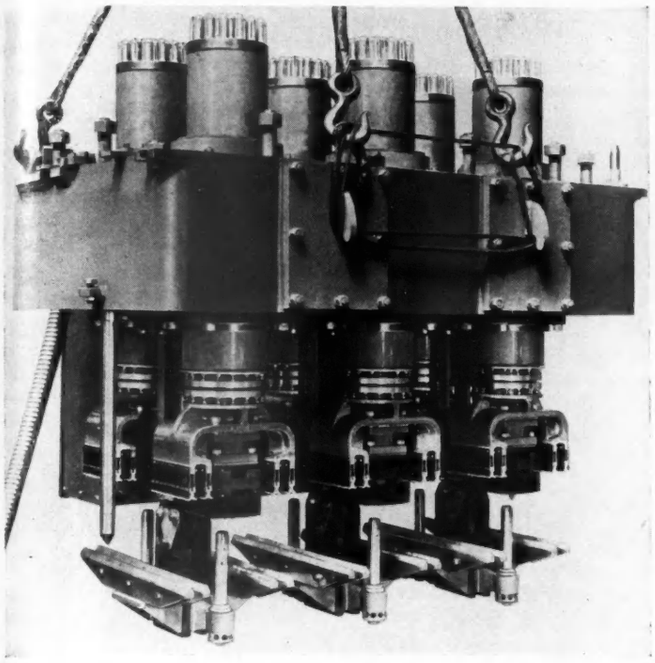


Fig. 2 An 11-kV 4,000-ampere circuit-breaker as installed at Nechells "B" power station, withdrawn from its tank to show contacts.

early 1930's the generating plant at this station was adapted to provide an 11-kV, 50-cycle supply, but the switchgear insulation was suitable for the new duty without alteration to the design.

After the new station had been planned a contract was placed with the General Electric Company for the modernisation of the old switchgear to suit the new conditions. This work involved the fitting of arc-control pots and contacts to the circuit-breakers on the main 25-panel switchboard, together with some alterations to the closing mechanisms, and the addition of new air-insulated gang-operated isolators. In some cases the current ratings of the circuit-breakers were increased, and all units were up-rated to a rupturing capacity of 1,000 MVA.

The circuit-breakers originally used for the ring and link main circuits were modified in a similar manner, and now have a rupturing capacity of 250 MVA. Three new 2,000-ampere control units have been added to these boards, bringing the total number of units to 29. Local control facilities have also been provided for both the main and group switchgear. For the main switchgear the local controls are fitted to relay panels mounted on the walls adjacent to the individual units, while in the case of the group switchgear they are mounted on a panel in the old control room.

NEW CONTROL ROOM

The 11-kV switchgear in both old and new stations, as well as the 132-kV switchgear, is operated from a main remote-control switchboard which is illustrated in Fig. 3. The overall length of this board is 102 ft. and as will be seen it is arranged in a "U" formation around the control desk. The board itself is of sheet-steel construction and incorporates a mimic diagram and instruments as well as components of the semi-miniature type. The control is arranged on the principle of an all-dark board except under fault conditions. In the event of a fault, the operator's attention is immediately drawn to the affected circuit by means of an alarm bell and a flashing light, which may be acknowledged either from the desk or the board.

The only lights appearing on the run of the board under normal conditions are the healthy-trip indicators, which are mounted above the mimic diagram and outside the all-dark zone. The centre panel of the switchboard is utilised for the general station alarms and the master clocks, and to the right of this are sections for the main switchgear for the first two sets, the synchronising equipment, the turbine and boiler gauge boards, and the first half of the 11-kV ring main. The corresponding sections to the left of the centre panel are for the second two sets, the synchronising equipment, the 132-kV switchgear and the second half of the ring main. Situated at the rear of the desk, and facing the main control board, is the 3·3-kV control board for the works supplies.

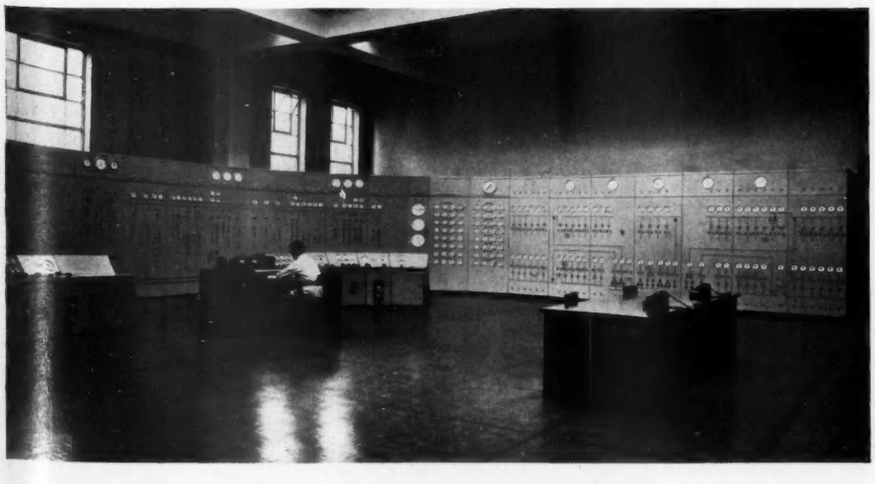


Fig. 3 The control room at Nechells "B" power station showing part of the main board and desks.

BUS-BAR PROTECTION

The whole of the main 11-kV bus-bar system is being equipped with General Electric load bias protective equipment, which is responsive to both phase-to-phase and phase-to-earth faults. The scheme operates on the circulating current principle in which the total current flowing into the protected bus-bars is compared with that flowing away from them, the resulting unbalance denoting an internal fault. A bias feature is incorporated to ensure a high speed of response with adequate sensitivity and stability. A separate set of bus wires is provided for each zone of the duplicate bus-bars, and the outputs from each current transformer group are switched to the appropriate bus wires by means of auxiliary contacts on the bus-bar isolators.

The protective equipment for the main switchgear for the first two sets is installed in the old control room and the corresponding equipment for the second two is housed, together with the relay boards, in an annexe to the new control room. A second annexe provides accommodation for the metering equipment for the entire station.

In addition to the equipment already described, the General Electric Company has supplied the field control and stand-by exciter equipments for all four sets in the new station, as well as the neutral earthing units for the alternators.

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LAUNCHES AND TRIAL TRIPS

M.S. "FJALLFOSS."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by Burmeister and Wain, Ltd., Copenhagen, Denmark, for H/f Eimskipafjelag Islands, Reykjavik, Iceland. Main dimensions: 280 ft. between perpendiculars by 42 ft. 11¾ in. by 26 ft.; deadweight capacity, 2,640 metric tons on a summer draught of 17 ft. 7 in.; cargo capacity, 4,880 cub. metres. Six-cylinder two-stroke single-acting trunk-piston Diesel engine, developing 2,180 b.h.p. at 180 r.p.m. Speed, 13·5 knots. Delivered, February 10.

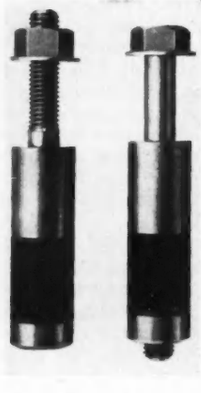
M.S. "ST. JOHN."—Single-screw cargo vessel, with accommodation for twelve passengers, built by Joseph L. Thompson & Sons, Ltd., Sunderland, for the South American Saint Line, Ltd., Cardiff. Main dimensions: 440 ft. between perpendiculars by 59 ft. 4 in. by 39 ft. 8 in.; deadweight capacity, about 9,600 tons on a draught of 26 ft. 9 in. Five-cylinder opposed-piston oil engine, developing 5,300 b.h.p. at 114 r.p.m., constructed by William Doxford & Sons, Ltd., Sunderland. Service speed, 14 knots. Trial trip, February 24.

S.S. "EDWARD CRUSE."—Twin-screw sludge vessel, built and engined by Lobnitz & Co., Ltd., Renfrew, for the London County Council, London, S.E.1. Main dimensions: 262 ft. between perpendiculars by 43 ft. 6 in. by 17 ft. 3 in. moulded; displacement, about 3,000 tons on a mean draught of 12 ft. 6 in.; four tanks capable of carrying 1,560 tons of sewage sludge. Two sets of triple-expansion steam engines, supplied by two Scotch forced-draught marine boilers. Maximum speed, 11 knots. Launch, March 9.

M.S. "CAPETAN KOSTIS."—Single-screw cargo vessel, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the Tramp Chartering Corporation, Panama. Main dimensions: 435 ft. between perpendiculars by 60 ft. by 39 ft. to shelter deck; deadweight capacity, about 12,000 tons on a draught of 29 ft. 9 in. Swan Hunter-Doxford four-cylinder oil engine, arranged to burn boiler fuel and developing 4.800 b.h.p. at 115 r.p.m. Trial trip, March 24.

RESILIENT MOUNTING BOLT

Many mounting and foundation bolts utilise expansion of the body to give the grip when they are tightened up; in the "Seetru" bolt part of the body is made of rubber and it is this which gives the grip. The bolts are made by L. H. Newton and Company, Limited, Nechells, Birmingham, 7. As may be seen in the illustration, tightening the bolt compresses the rubber between two steel cylinders and a strong resilient grip is produced. In friable material, vibration on the bolt does not cause the fretting and breakdown that occurs with a metal body; moreover, the resiliency of the rubber acts as a lock-nut or spring-washer preventing any slackening of the bolt.



For concrete foundations, the holes for the bolts can be drilled after pouring the concrete, using a drill to suit the outside diameter of the bolt. The resiliency of the rubber relieves the concrete of some of the transmitted vibrations, which may enable a less bulky foundation to be used. The grade of rubber has been chosen for its good resistance to oils and spirits. The bolts may be either male or female, the former being more suitable for wall fixtures while the latter enable plant to be slid into position without lifting.

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POWER PLANTS AND STAINLESS STEELS

Film in Colour

A film entitled "Stainless Steels in Power Production," which illustrated the manufacture, fabrication and use in power plants of various stainless steels, was the principal item in a programme of colour films presented on Friday, March 26, in London, by Firth-Vickers Stainless Steels, Limited, Staybrite Works, Sheffield, 9. It was the fourth in a series of similar films and had been prepared originally for the Spring meeting of the Institute of Welding held in Sheffield last May. Mr. F. G. Dickinson, London manager of Firth-Vickers, introduced the films, which, he said, had been made entirely by the Company's own unit.

In the film were shown power plants ranging from pelton wheels and water turbines to gas turbines and jet engines, all of which employ stainless or special steels in their construction. Centrifugal die casting, the lost-wax process, spot, stitch and seam welding, brazing, heat treatment, nitriding and welding by argon-arc were among the processes illustrated. In addition reference was made to the different types of steel used on power installations. These included straight 18/8 chromium-nickel steels, modified by titanium in order to prevent weld-decay, and chromium tungsten steel, which, in the form of inserts, is used to protect turbine blading from the corrosive effect of low-pressure steam.

The film, which has a spoken commentary and a running time of 31 minutes, was made under the technical direction of Mr. J. A. McWilliam of Firth-Vickers' research department. It was preceded in the programme by a short film taken at Farnborough during the display of the Society of British Aircraft Constructors last September to indicate the part played by special steels in the construction of modern aircraft and aero-engines.

Both films were processed by Kodak Limited, Wealdstone, Harrow, Middlesex, and are available for distribution to other organisations.

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MECHANICAL LOADER FOR LOOSE MATERIALS AND STRIPPING OVERBURDEN

Two Three-Point Suspension Systems

The new "Muir-Hill" mechanical loader, built by E. Boydell and Company, Limited, Elsinore-road, Old Trafford, Manchester, 16, has been so designed that it is able to scoop up loose material and discharge it into hoppers over 11 ft. high or to strip overburden and traverse rough ground in safety.

Basically, it comprises two units: a Fordson Major Diesel tractor of 42 brake horse-power, less its front axle, and a frame made from rolled-steel sections carrying the lifting gear and a front axle. The frame is connected to the tractor at two points: beneath the rear of the tractor by a longitudinal kingpin and below the radiator by a pivot pin. This arrangement gives two independent three-point suspension systems working in opposition and hence a much greater degree of articulation between the steering axle and the driving axle, making for greater stability and enabling it to be driven over rough ground with safety while the loaded bucket is in its uppermost position.

OPERATION OF JIB

The method used for raising the jib and bucket gives a maximum clearance beneath the lip of a standard $\frac{3}{8}$-cub. yard bucket of 14 ft. 6 in. when the reach is 1 ft. 6 in. The jib pivots about a fixed point at the top of the frame, as can be seen in the illustration. From the centre of the jib two struts extend downwards. They are attached to the jib by pivots and carry a flanged wheel at their lower end, which rests on the front uprights of the frame. The uprights serve as tracks for the wheels and a stop is placed at the top of the upright to prevent over-running when the point of maximum lift is reached. A $\frac{3}{4}$-in. diameter wire rope extends from the lower end of one strut adjacent to the wheel over the pulley wheel, which can be seen in the illustration at the front of the frame, to a compensating beam and then down on the far side to the nose of the other strut.

A winch mounted at the rear of the tractor is coupled by a $\frac{7}{16}$-in. diameter winding rope through a pulley system to the compensating beam and when in operation it hauls the beam back along the frame drawing up the struts and thereby raising the jib.

FRICTION DRIVE

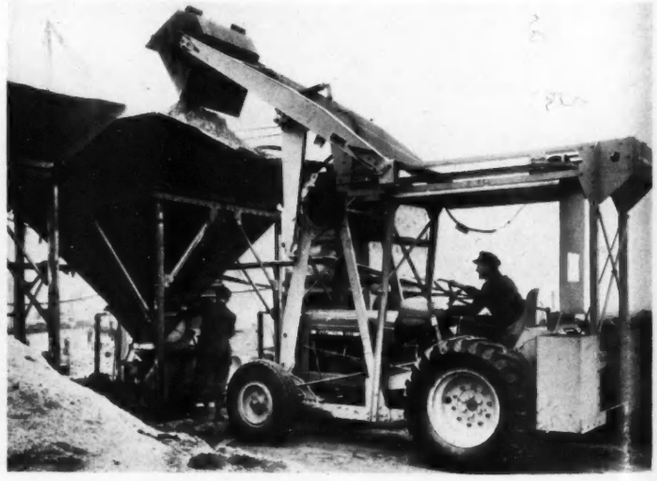
The winch drum is rotated by a friction roller driven from the power take-off by a roller chain. The drum is mounted on an eccentric shaft and is normally held against a set of brake shoes by a spring-loaded hand lever. To raise the bucket the drum is pulled away from the brake shoes by the lever and held against the friction roller. If the lever is held in a midway position the winch drum is free to revolve and the bucket descends, at a governed rate, under its own weight.

A heavy steering gear replaces the unit normally fitted to the tractor. It is of the cam and roller type and is designed to resist shocks incurred when traversing uneven ground surface.

Ballast boxes are fitted at the rear of the frame and the quantity of ballast can be arranged to suit operating conditions. The standard bucket is of the tipping type constructed from mild-steel plate and fitted with a hardened-steel blade. This can be replaced by a 1-cub. yard bucket of standard or full width or by a $\frac{1}{2}$-cub. yard model fitted with teeth for handling rock. The buckets are gravity tipped and will operate at any height. They are controlled from the driving seat and re-set automatically when the jib is lowered.

The complete loader is 17 ft. 6 in. overall when the bucket is at ground level, 6 ft. $7\frac{1}{4}$ in. wide and the height with the bucket lowered is 9 ft. $4\frac{1}{2}$ in. With the bucket raised to the maximum position the height becomes 19 ft. $1\frac{1}{2}$ in. The total weight of the loader is about 4 tons 10 cwt.

Among the other equipment which can be fitted to this machine is a light dozer blade and shoe which fits directly on to the bucket; it is not suitable, however, for those machines fitted with scoops. A 1-ton crane hook can also be fitted below the bucket to provide a permanent lifting arrangement available at all times. Alternatively, the entire bucket assembly may be replaced by a crane jib, when a longer winding rope is used; the maximum lift then available is 1 ton.



The jib of this loader pivots from the top of the frame and is raised by a winch driven from the power take-off through a friction roller. The maximum clearance beneath the lip of the standard bucket is 14 ft. 6 in.

1,000-H.P. DIESEL-ELECTRIC LOCOMOTIVE FOR BRAZIL

The illustration below shows one of thirteen A-1-A – A-1-A 1,000-h.p. Diesel-electric locomotives which are being supplied by the English Electric Company, Limited, Kingsway, London, W.C.2, for the metre-gauge system of the Rede Ferroviaria do Nordeste, formerly the Great Western of Brazil Railway. They will be used on the Central line from Recife to Afogadas de Ingazeira (250 miles) and on the Southern line to Maceio (216 miles), mainly for hauling passenger trains. They will, however, also be employed to assist in the movement of heavy seasonal crops of sugar and cotton. The maximum gradient is 1 in 40 and the sharpest curves have a radius of 260 ft.

As will be seen, the locomotives have two three-axle bogies, the outer axles of which are motored. They have a total wheelbase of 39 ft. and a bogie wheelbase of 12 ft., while the weight in working order is 71 tons. They are capable of exerting a continuous tractive effort of 20,400 lb. and the maximum speed is 60 m.p.h.

MECHANICAL CONSTRUCTION

The mechanical parts of these locomotives are being built by the Vulcan Foundry, Limited, Newton-le-Willows. The underframe is of fabricated construction; the main longitudinal members are of the truss type and are deepened at the centre to form the sides of the 540-gallon fuel tank. They are braced with cross-stretchers and gussets and the automatic coupler drawgear is mounted on fabricated drag boxes at each end. The framework of the superstructure, which is fabricated as a unit, is made up of rolled-steel sections and angles and the whole is welded to the underframe. The bogies are of the swing-bolster type, the fabricated frames being carried on four nests of springs, which rest on equalising beams. The load from the superstructure is transmitted to the beams through a bolster and four groups of laminated springs. Two of these groups rest on either spring plank, which is suspended from the transoms by inclined swing links. Lateral movement is limited by stops. The road wheels are of the rolled-steel disc type with shrunk-on tyres secured by retaining rings.

POWER UNIT

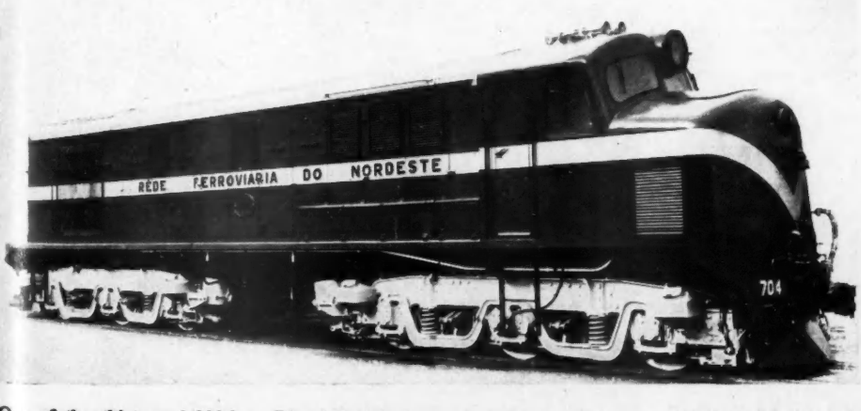
The engine, which is of English Electric manufacture, is an eight-cylinder four-stroke type with a continuous rating of 1,000 brake horse-power at 850 r.p.m. Owing to the atmospheric conditions in Brazil it has, however, been de-rated to 874 brake horse-power. It is fitted with two Napier exhaust-gas turbo-chargers, each of which serves four cylinders. The fuel supply, from an electrically-driven pump, is regulated by a governor, which is driven from the camshaft at the flywheel end of the engine and operates through a servo mechanism.

The flywheel housing of the engine is bolted to the frame of the main six-pole direct-current generator. The other end of the generator frame is machined to receive an end-shield to which the overhung auxiliary generator is fixed. This auxiliary generator supplies current at 110 volts for excitation and to the control circuits, blower and exhauster motors as well as for lighting and battery charging. The engine and both generators form one unit, which is supported at three points on resilient mountings. The traction motors are series-wound six-pole forced-ventilated machines and are provided with two stages of automatic field weakening so that constant wheel-tread horse-power can be obtained throughout the speed range. They are permanently connected in two parallel groups of two in series and drive the road wheels through single-reduction spur gearing.

CONTROL SYSTEM

Control is effected from the cab by a master switch, control handle and brake valve. The engine is started by moving the master switch to the "engine only" position and then pressing a starting button. To start the locomotive the master switch is moved to the appropriate position for selecting the direction required, thus closing the correct motor contactors and connected the traction motors to the generators. At the same time, the generator field is slightly excited, thus providing sufficient tractive effort for manœuvring at low speeds. Further movements of the control handle gradually increase the fuel injection and subsequently the engine speed. After the initial movement of the control handle the main excitation is automatically regulated so that the generator output matches the available engine horse-power irrespective of its speed.

Up to three locomotives can be coupled together and driven in multiple from one cab.



One of the thirteen 1,000-h.p. Diesel-electric locomotives for the metre-gauge Rede Ferroviaria do Nordeste, Brazil.

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45-H.P. MINES DIESEL LOCOMOTIVE

Design for Light Rails

A fifth model, for running on light rails, has recently been added to the range of fully-flameproof Diesel locomotives for underground service built by the Hunslet Engine Company, Limited, Jack-lane, Hunslet, Leeds, 10. It has been designed specifically to meet the requirements introduced with the new Coal Mines (Locomotives) Regulations, 1949, which state that locomotives up to 5 tons in weight may run over 28-lb. rails, whereas any heavier unit must operate on rails weighing 40 lb. a yard or over. There are three versions of this new 45-h.p. model: (1) fully flameproofed and exhaust-conditioned for gassy mines; (2) exhaust-conditioned only for metalliferrous workings; and (3) without flameproofing or exhaust-conditioning for surface duties.

It is built on the sames lines as other Diesel locomotives for underground work made by this company. A Hunslet clutch and mechanical transmission are used and a jackshaft drives the wheels. The Gardner-3LW engine is set to develop 45 brake horse-power at 1,700 r.p.m., which gives track speeds of 5 and 10 m.p.h. in either direction. The locomotive can be made for any gauge from 1 ft. 11½ in. to 3 ft. 6 in. The other main details are: 20-in. wheels; 42-in. wheelbase; 11 ft. 2 in. length over buffer beams; 4 ft. 6 in. maximum height; width equal to gauge plus 14 in.; tractive effort, 2,800 and 1,400 lb. in two gear steps; minimum negotiable curve 40-ft. radius; and Westinghouse air brakes are fitted when required for man-riding cars or for coal and ore tubs with continuous brakes.

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SIDE AND FACE MILLING CUTTERS

A new range of side and face milling cutters is being marketed by Clarkson (Engineers), Limited, Nuneaton. Made from an 18 per cent. tungsten high-speed tool steel, the successive teeth of the cutter are ground on opposing helices having lead angles of 10 deg., so that good advantage is taken of a shearing, rather than a ploughing, cutting action. The faces of the teeth are ground to a positive rake of 7½ deg. and the back relief is of such a form as to ensure a strong tooth.

The cutter sizes available are 3 in., 4 in., 5 in. and 6 in. in diameter, the smallest having a face width of between $\frac{1}{16}$ in. and $\frac{3}{4}$ in., the largest between $\frac{3}{8}$ in. and 1 in. The permissible cutting speeds are said to be high. A 3-in. diameter cutter with a face width of $\frac{5}{8}$ in., working at 112 r.p.m., was used to make a ½-in. deep cut in mild steel and was fed into the work at 6⅞ in. per minute. On a second cut, this time ¾ in. deep, a feed of 4 in. per minute was obtained at a cutter speed of 121 r.p.m. In a bar of 30-ton steel, a 5-in. diameter cutter with a $\frac{5}{8}$ in. face width was used to make a ½ in. deep cut at 70 r.p.m. and a feed of 6½ in. per minute was obtained. The same cutter was then used on a 60-ton steel at 35 r.p.m. and it was possible to make a ½-in. deep cut at 3½ in. per minute.

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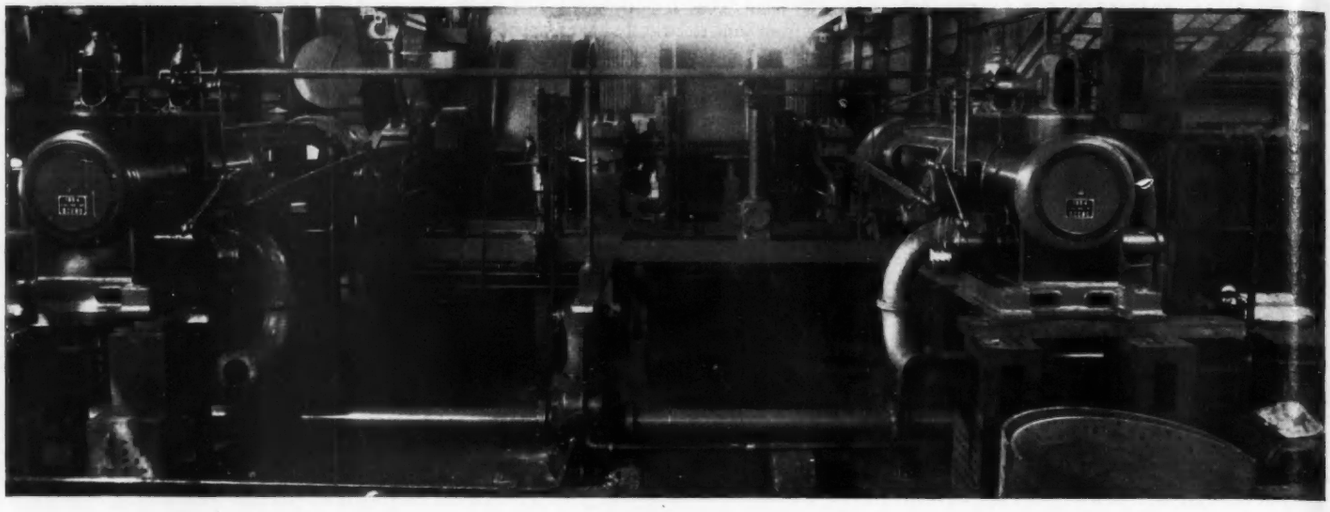
TRAVEL FOR EDUCATION

Residents of member countries of the Organisation for European Economic Co-operation are to have greater facilities for visiting other member countries to pursue academic or professional studies, and to attend educational centres. From now on, for a period not exceeding one year for each payment, member countries will authorise the transfer of sums to cover fees payable for education at a university, a vocational college or, up to a reasonable amount, at a secondary or primary school. They will also authorise the transfer of the necessary sums for the payment of living expenses.

Up to now, member countries have undertaken only to treat requests for transfers in as liberal a manner as possible. The new decision makes it compulsory for them to permit such transfers. It applies to all O.E.E.C. member countries except France, Greece, Iceland and Turkey, owing to their balance-of-payments deficit or their economic situation. Italy and Sweden have also indicated that they are not at the moment in a position to adopt this decision, although their policy in this respect is very liberal; the position of these two countries will be reconsidered in six months' time.



The throttle valve, steam and exhaust pipes, and helical gears are visible in this view from the cylinder-head end.

A LARGE STEAM HAULAGE ENGINE

INCLINE WINDING AT A COLLIERY

Although the steam engine has largely given way to other forms of prime mover, it still has its uses where steam can be generated economically. As part of a development scheme at Easthouses Colliery, Lothians Area, Scottish Division, National Coal Board, low-grade coal will be used in the boilers, and a large horizontal steam engine, which is expected to be the last machine of its kind to be built for mines in this country, will haul the coal up an incline to the surface.

The engine has been built by Walker Brothers (Wigan), Limited, Pagefield Ironworks, Wigan, Lancashire. It is of the double-drum reversing type, designed to haul two pairs of 9-ton automatic drop-bottom cars on an incline of approximately 1 in 2, and 4,355 ft. long. The cars will travel at 12 m.p.h. (17½ ft. per second), and will complete the 3,630-ft. cable run in about 3½ minutes; the complete cycle, allowing for loading and unloading, will be about 6 minutes. The quantity of coal hauled per shift will be about 1,000 tons. Steam will be supplied to the engine at 140 lb. per square inch at the throttle valve, and 140 deg. F. superheat, the total steam temperature being 500 deg. F. The engine is designed to work with 7 lb. per square inch back pressure.

There are two non-compound cylinders, arranged horizontally at 27 ft. 7 in. centres, the bore and stroke of both cylinders being 26 in. and 4 ft. 6 in., respectively. The cylinders are lagged with non-conducting material, enclosed with planished sheet steel secured with steel bands. Cast-iron pistons, with Ramsbottom-type piston rings, are secured to the mild-steel piston rods by wrought-iron nuts. The cross-heads, working in trunk-type bedplates, are of cast steel, with loose adjustable cast-iron shoes.

Steam admission is controlled by drop-type double-beat valves, while the exhaust valves are of Corliss pattern. Valve actuation is from two pairs of eccentrics on the crankshaft, operating through an Allan straight-link reversing motion, with a steam reversing engine. A centrifugal governor, rope-driven from the crankshaft, is provided to control the cut-off, and thus ensure maximum steam economy. The crankshaft, which is 15½ in. in diameter, is supported in three bearings, the centre bearing being 15½ in. diameter by 23 in. long, and the two outer ones 14 in. diameter by 21 in. long. Overhung cranks, of cast steel, set at 90 deg. to each other, are shrunk and dowelled on to the shaft.

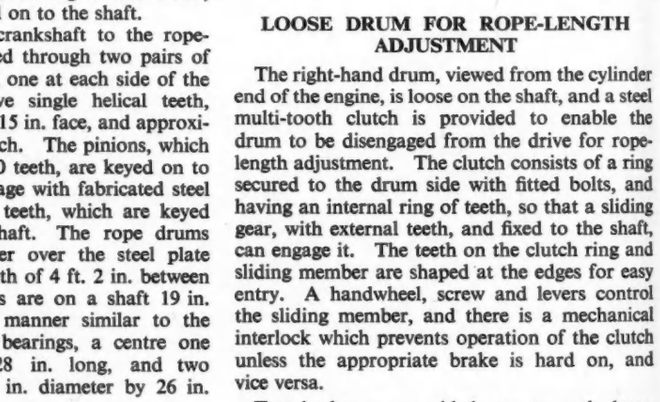
The drive from the crankshaft to the rope-drum shaft is transmitted through two pairs of single-reduction gearing, one at each side of the engine. The gears have single helical teeth, with a ratio of 3·2 to 1, 15 in. face, and approximately 2½-in. normal pitch. The pinions, which are of cast steel, with 70 teeth, are keyed on to the crankshaft, and engage with fabricated steel gearwheels, having 224 teeth, which are keyed on to the rope-drum shaft. The rope drums are each 14 ft. diameter over the steel plate barrels, with a clear width of 4 ft. 2 in. between the flanges. The drums are on a shaft 19 in. diameter, carried in a manner similar to the crankshaft, with three bearings, a centre one 19 in. diameter by 28 in. long, and two outer bearings each 17 in. diameter by 26 in. long.

The drum sides, which are of cast steel, are made in halves, with machined joints, the fixing bolts being double-nutted and locked with split pins. Mild-steel plate rope barrels are mounted between the drums' sides, the latter being machined to receive the barrel plates, which are fixed with countersunk bolts. The barrels are scrolled, the machining being carried out after assembly, compressed air being used to drive the engine for this purpose. One side of each drum is provided with a solid-cast brake-path.

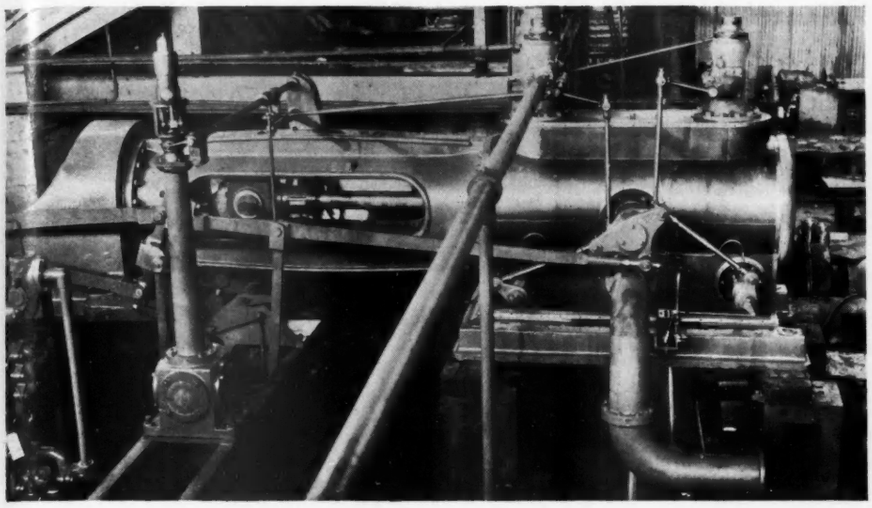
LOOSE DRUM FOR ROPE-LENGTH ADJUSTMENT

The right-hand drum, viewed from the cylinder end of the engine, is loose on the shaft, and a steel multi-tooth clutch is provided to enable the drum to be disengaged from the drive for rope-length adjustment. The clutch consists of a ring secured to the drum side with fitted bolts, and having an internal ring of teeth, so that a sliding gear, with external teeth, and fixed to the shaft, can engage it. The teeth on the clutch ring and sliding member are shaped at the edges for easy entry. A handwheel, screw and levers control the sliding member, and there is a mechanical interlock which prevents operation of the clutch unless the appropriate brake is hard on, and vice versa.

Two brakes are provided, one on each drum. They are of the suspended type, built up of steel plates and angles. The brake shoes are of fabricated steel, with the friction fabric secured



The rope drums during assembly in the shops. The brake gear has not been erected owing to lack of space.



The right-hand cylinder, showing the valve gear and centrifugal governor.

by brass countersunk bolts. Heavy cast-iron fulcrum brackets are used to carry the suspension links. Adjustable steel tie-rods are provided between the two halves of each brake, to allow for lining wear. Operation of the brakes is by means of levers and deadweights, the arrangement being that the brakes are normally "on" unless steam is admitted to the undersides of the pistons of the brake engines to release them. Each brake engine has a cataract cylinder, in which the flow of the fluid can be regulated to suit the amount of braking effort required.

CONTROL GEAR AND SAFETY DEVICE

The controls, comprising throttle, reversing lever and footbrake, are on the left-hand side of the engine, looking from the cylinder end, and a driver's platform is provided at this point. The throttle operates directly through levers, while the reversing lever and footbrake control the reversing engine and the two brake engines, respectively. A large dial-type indicator faces the driver's platform, to indicate the position of the cars on the incline. It is driven by spur gears from the end of the crankshaft.

There is an overspeed and overwind prevention device of the manufacturers' own patented design, which cuts out the manual controls, closes the throttle, applies the brakes, and stops the engine at the end of the wind, should the driver fail to do so. It also takes control if the driver operates the engine at too great a speed. The safety device consists of a screw driven from the engine crankshaft by bevel gears, and carrying a wheel which is slotted on its periphery. This wheel represents the position of the cars on the incline. Mounted above the wheel are three hinged plates, cut to a special profile, and connected to trip gear which operates the throttle control and brake engines. The height of these plates above the wheel is regulated by a sensitive centrifugal governor driven by the bevel gears. Any increase of speed above the designed figure causes the profile plates to be lowered. They are then fouled by the slotted wheel; this swings them sideways, and operates the trip gear.

The centre profile plate has a straight edge, which permits the engine to run at a constant speed in the middle of its travel. The two end plates, which represent the ends of the wind, are cut to a shape which requires progressive lifting if they are not to be tripped, and this lifting is performed by the governor if the driver reduces speed correctly. Overwinding, or starting the engine in the wrong direction, are prevented by two toothed quadrants bolted to opposite sides of the wheel, which strike the extremities of the profile plates, and so trip the gear. The control device is provided with a dashpot, which ensures that the brakes are not applied suddenly if the trip operates, but instead applies them as quickly as is consistent with safety. When the device has tripped, it has to be re-set, and a lever is provided on the driver's platform for this purpose. Two sets of profile plates are incorporated in the device, the second set being arranged to project below the normal ones; these are moved into position by a control lever, and provide for reduced speed when man-winding is in progress.

The cylinders are lubricated by force-feed lubricators driven from the exhaust valve spindles. Lubricators of normal pattern are provided for other parts of the engine, and the two pairs of gears driving the rope drums are enclosed in fabricated steel, dust-tight gear cases, which act as oil baths.

The engine will operate at a maximum speed of 75·5 r.p.m. at the crankshaft and 23·5 r.p.m. at the rope-drum shaft. It has a designed brake horse-power of 650-700.

The principal details of the engine are summarised in the following table:

Steam Pressure and Temperature:	
140 lb. per sq. in. at throttle valve.	
150 lb. per sq. in. at boilers.	
140 deg. F. superheat.	
500 deg. F. total temperature.	
Steam Cylinders (2):	
Diameter	26 in.
Length of Stroke:	
Diameter	54 in.
Piston Rods:	
Diameter	5½ in.
Connecting Rods:	
Length centre to centre	12 ft. 6 in.
Diameter at crank end	6½ in.
Diameter at crosshead end	5½ in.
Crank Pin:	
Diameter	7 in.
Length	9 in.
Crosshead:	
Pin diameter	6 in.
Length	7½ in.
Crankshaft:	
Diameter in body	15½ in.
Diameter of end journals	14 in.
Length of end journals	21 in.
Diameter of intermediate journal	15½ in.
Length of intermediate journal	23 in.
Drums:	
Diameter	14 ft.
Width	4 ft. 2 in.
Drum Shaft:	
Diameter	19 in.
Diameter of end journals	17 in.
Length of end journals	26 in.
Diameter of centre journal	19 in.
Length of centre journal	28 in.
Engine Centres	27 ft. 7 in.

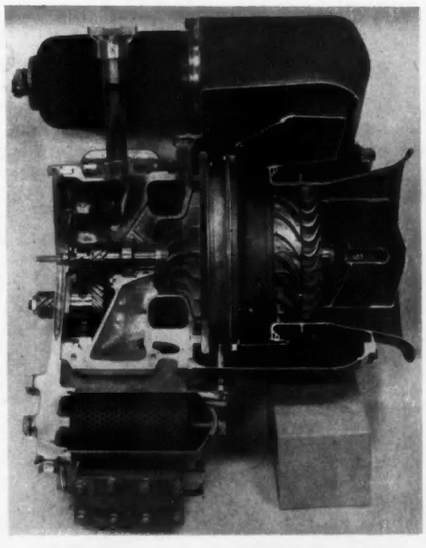
LIGHTWEIGHT PORTABLE GAS TURBINE

A 60-B.H.P. INDUSTRIAL UNIT

The smallest gas turbine to go into production up to the present has been introduced by Rover Gas Turbines Limited, Solihull, Birmingham, a subsidiary of the Rover Company Limited. The parent company undertook extensive experimental work on small gas turbines, which resulted in the introduction of the world's first gas-turbine powered motor car in 1950, driven by a power unit of 250 h.p. In the early stages of this development work it was realised that the first practical application for the small gas turbine would be in the industrial field, and it was decided to concentrate on the production of two smaller units, with as many common parts as practicable. The first of these units was to be of the single-shaft type, without a heat exchanger, and of 60 brake horse-power, while the second was to be of the two-shaft type with heat exchanger. The 60 brake horse-power single-shaft turbine is now in production.

TURBINE CONSTRUCTION

The unit is equipped with a single-stage, single-sided, 17-vane centrifugal compressor of light alloy, with steel rotating guide vanes, shrunk on to a hardened steel shaft. A single-stage, integrally bladed Nimonic 90 turbine disc, with 31 blades, is attached to the same shaft. The shaft rotates in a clockwise direction when viewed from the compressor end. At the forward end of the shaft, retained by a special nut, are the inner race of the angular contact location bearing, and the high-speed pinion, which drives the fuel control unit and the oil pump through a train of gears. Towards the rear of the shaft is the track for the rollers of the turbine bearing, the detachable outer race being a part of the bearing sealing system. The outer



The 60-b.h.p. Rover industrial gas-turbine sectioned to show its construction.

race of the location bearing, which absorbs any residual thrust, is seated in the compressor housing.

The housing is closed at the forward end by the auxiliaries mounting plate, to which are attached the fuel control unit and the oil pump, complete with its suction filter. Integral with the intermediate wheel of the train of gears driving the oil pump and fuel control unit is a shaft which protrudes through the mounting plate and carries the output drive pinion. The mounting plate also carries a "full-flow" Purolator oil filter. The base of the housing forms an oil sump of 5½ pints capacity for the wet sump lubrication system. The breather pipe and filler cap are on the top of the housing. Air intakes are provided on each side of the housing, and are fitted either with wire mesh gauzes or intake silencing stubs complete with oil coolers.

Bolted to the rear of the compressor housing is the stainless-steel main casing, which houses the complete ductwork, including the air duct from the compressor and the volute leading to the turbine, part of which is formed by the Nimonic 75 heat shield. The main casing also contains the alloy bearing housing support plate, the oil drain assembly, and the diffuser. The latter, although situated inside the main casing, is not attached to it, but is located between the compressor housing and the support plate by a ring of bolts. A flange on the front of the casing carries the Lucas high-heat-release combustion chamber, complete with its back-spill burner and igniter plug. Protected by the heat shield is the turbine bearing sealing system, the components of which are bolted to the rear of the support plate, which, in turn, is attached to the compressor housing by the ring of bolts which locates the diffuser. A similar form of labyrinth seal is incorporated adjacent to the compressor bearing.

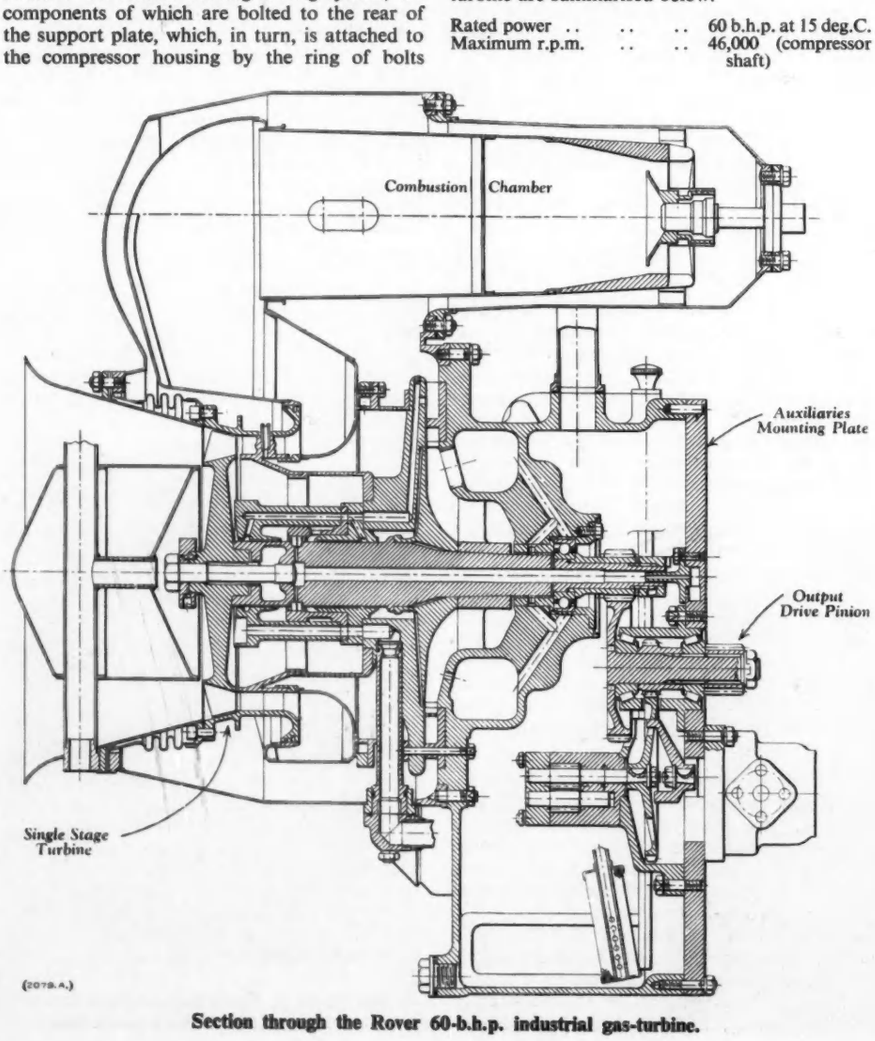
A ring of bolts secures the nozzle support ring to the support plate. Welded to the rear of this ring is the heat-resisting nozzle ring, the nozzles, 21 in number, being secured to the combined shroud ring by a series of pegs. The front flange of the stainless-steel exhaust cone assembly is bolted to the end flange of the shroud ring, while the rear flange of the cone is joined in a similar manner to the rear flange of the main casing. These two pairs of flanges are interconnected by a flexible bellows, which allows the exhaust cone to expand without distorting.

HAND STARTING

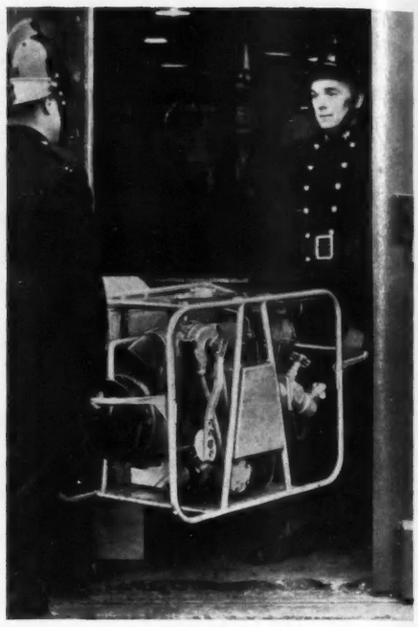
The turbine is started by a hand mechanism, which is attached to a bracket on the main casing. It consists of a starting handle, which is arranged to fold inwards, and a chain and gear drive, with a ratio of 100 to 1, which meshes with the oil-pump drive wheel. The hand starting gear also drives a high-energy spark generator, which supplies current to the igniter plug. The fuel control unit comprises a Plessey dual-fuel pump and a Lucas combined governor and temperature control, part of which is situated in the exhaust cone assembly and connected to the control unit by capillary tubing. This fuel control unit controls the turbine automatically, the only manual control being a shut-off cock, which is used for stopping.

The principal performance details of the turbine are summarised below.

Rated power	60 b.h.p. at 15 deg.C.
Maximum r.p.m.	46,000 (compressor shaft)
Output shaft, r.p.m.	According to requirements
Specific fuel consumption ..	1·46 lb. per b.h.p. per hour
Air mass flow	1·35 lb. per second
Compression ratio	2·9 to 1
Maximum jet-pipe temperature	600 deg. C.
Maximum gas temperature ..	790 deg. C.
Overall thermal efficiency at 15 deg. C.	9·5 per cent.
Weight/power ratio	1·93 lb. per b.h.p.
Dry weight	116 lb. ± 2½ per cent.
Speed governing	± 1 per cent.
Fuel	Any distillate fuel, and certain gaseous fuels



Section through the Rover 60-b.h.p. industrial gas-turbine.



The gas-turbine used in a portable fire pump made by Sigmund Pumps, Limited.

DRIVING A FIRE PUMP

A typical application of the Rover gas turbine is its use with a fire pump made by Sigmund Pumps, Limited, Team Valley, Gateshead, 11. For this purpose the turbine is mounted in a light fabricated tubular frame, the overall weight of the equipment, complete with fuel tank and instrument panel being approximately 200 lb. The overall dimensions are: height 25⅝ in., width 20½ in., length 33½ in.

The pump is a specially designed single-stage unit, having a capacity of 400 gallons per minute at a total delivery head of 231 ft., when pumping from a 10-ft. static lift with three lengths of 4-in. smooth-bore suction hose and a strainer. Discharge can be taken from two 2½-in. discharge pipes, with delivery valves of approved type and standard hose connections. The suction eye has a standard 4-in. suction hose connection, with a removable internal strainer and blank cap.

The pump impeller rotates at 4,500 r.p.m., the speed reduction being obtained partly by gearing in the turbine, and partly by gearing incorporated in the pump itself. Drive for the pump is taken from a gearwheel fitted on splines and supported in a double-row conical roller bearing lubricated with oil under pressure from the turbine, the oil being injected into the bearing through a hollow shaft, and returned via the gear casing to the turbine sump. The bearing housing and gear chamber are part of the liquid space of the pump, and are thus cooled by the liquid being pumped. There is a plug on the pump casing which can be used to take off cooling water if required. A mechanical seal is used for

the stuffing-box, any liquid collecting between the oil seal and the mechanical seal being led away through a drain hole. For priming the pump there is an air ejector taking air from the compressed air receiver of the turbine. It is designed to lift water 24 ft. at not less than 1 ft. per second at atmospheric pressure, and is operated by a single lever.

A fuel tank holding sufficient fuel for 25 minutes' operation is fixed in the tubular frame, and there is an instrument panel with the following instruments: for the turbine, oil pressure gauge, revolution indicator, oil temperature gauge, on/off fuel control valve; for the pump, compound pressure gauge (suction), discharge pressure gauge, priming control. Carrying handles, which fold down when not in use, are fitted to each end of the frame. Alternatively, the pumping unit can be mounted on a fabricated trailer, complete with tow-bar, hand and overrun brake, hose carriers and toolbox.

* * *

RETAINING WALL BUTTRESSED

Stabilising a Railway Bank

Because of unusual difficulty in maintaining the level and line of the rail tracks at a point between Brighouse and Elland, Yorkshire, where the railway runs 42 ft. above the River Calder, British Railways (North Eastern Region) have had to strengthen the massive stone retaining wall which supports the tracks.

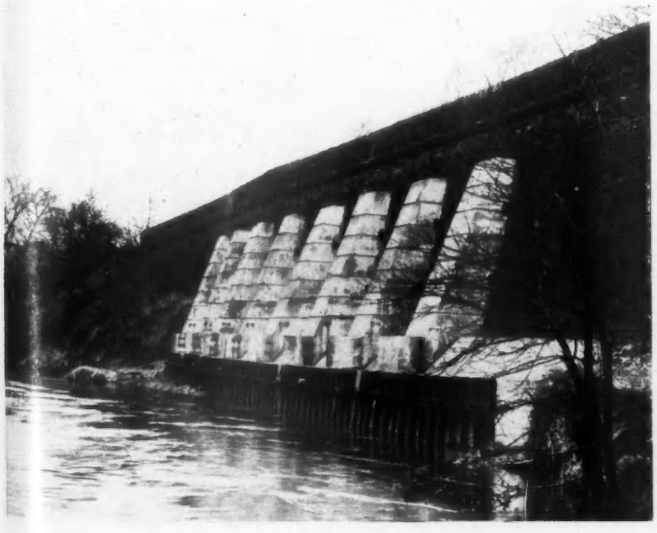
This portion of railway, on the Manchester to Wakefield main line, was opened in 1840, and the double track, following the general course of the river, is carried on a shelf constructed on the slope of a natural hillside and held in position by the retaining wall.

During the summer of 1951, instability in the support of the track was discovered. Datum lines and levels were set up from which accurate records of movement of the retaining wall could be obtained. By January, 1952, these records confirmed that an outward movement of a section of the wall was taking place, accompanied by a smaller vertical settlement. As a first step a re-alignment of the two running lines was carried out whereby they were pulled some 5 ft. inward towards the hillside and away from the retaining wall. Rail straps to safeguard against the effects of local settlement were added to both tracks and a speed restriction of 5 m.p.h. was imposed over the length affected. Despite the serious deformation of the wall which had taken place up to this date, the facework was found to be generally sound.

Meanwhile, a strengthening scheme was prepared which provided for continuous steel-sheet piling to be driven in front of the toe of the retaining wall throughout the length adjacent to the river, and mass concrete taken down to a level some 3 ft. lower than the foundation level of the old wall between the piling and the wall. Provision was also made in the scheme for the subsequent construction of buttresses if found necessary, to safeguard still fruther the general stability of this length of retaining wall. The contract for the work was let to Wellerman Brothers, Limited, Sheffield, and pile-driving was begun early in February, 1952. Though some difficulty was experienced in obtaining the penetration of the piles as required by the scheme, the work was carried out generally in accordance with the plan. Excavation and concreting between the piling and the wall were carried out in sections, involving considerable pumping, and the whole of this stage of the strengthening work was completed in August, 1952. Records kept of movement of the wall showed a progressive reduction, and from August no further movement was recorded.

While the ashlar face of this heavy retaining wall appeared to be in very sound condition, some uncertainty existed as to the condition and quality of the masonry of the wall behind the facing. During the progress of the strengthening work in front of the wall, trial pits were sunk behind the wall and examination made of the masonry, when it became apparent that considerable voids existed in the main body of the wall.

Experimental work was, therefore, undertaken in pressure grouting from the outside face of the wall, but it was found that grouting conditions were particularly difficult and that it was not possible to ensure satisfactory impregnation without excessive waste of material. It was decided, therefore, that eight concrete buttresses, 25 ft. high, should be built from the new concrete strengthening work along the length where the greatest movement had taken place. These buttresses were built without difficulty and securely bonded to the masonry of the wall; each construction joint was strengthened by embedding three old rail sections, 5 ft. long. Their construction was completed in January, 1953. There was little doubt that one of the factors which had given rise to the development of instability in this retaining wall was the considerable penetration of surface water from the adjacent hillside into the wedge of filling supported by the wall. After stability had been re-established the tracks were re-instated on their original alignment, and the opportunity then taken to provide improved surface-water drainage in the cess at the foot of the hillside. The work was completed in the Spring of 1953, under the general direction of Mr. A. Dean, M.Sc., M.I.C.E., civil engineer to the Region.



Trial pits had shown that the body of this wall contained many voids which grouting failed to fill satisfactorily. The wall supports the railway line between Brighouse and Elland, in Yorkshire, where it runs adjacent to the River Calder, and it has been strengthened by constructing additional footings and the eight buttresses shown here.

* * *

HIGH-SPEED PASSENGER LIFTS

Installed by London Transport

As part of a programme for modernising lift equipment at a number of stations on the London Transport Underground railway system, two high-speed lifts were brought into service on Monday, April 12, at Hampstead on the Northern line. The new lifts replaced two of four existing lifts which had been in use since the line was opened in 1907. The " travel " from booking-hall level to the lower level is about 181 ft., sufficient to allow a speed of 800 ft. per minute to be attained, reducing the journey time between landings from 53 to 21 seconds. This lift speed is the highest in the United Kingdom, and is believed to be exceeded only by those obtained in the United States, where by reason of the longer travel many run at 1,200 ft. per minute.

Each new car is designed to carry 30 passengers, but will take up to 40 under heavy traffic conditions; though the capacity of the new cars is less than that of the older type, the higher speed of the new cars means that total capacity of the lifts is not materially changed from 1,400 passengers per hour. The control equipment allows the lifts to be set to operate continuously without attention from the staff; variations in traffic demands are met by adjustment of the dwell period spent at the landings. Manual control by the staff can be effected, however, by means of push buttons located in boxes (normally locked) on both landings and inside the cars.

SAFETY DEVICES

Illuminated signs show the position of each lift in the shaft and also indicate the next lift to leave. When operating under automatic control, the signs light up to warn passengers six seconds before the doors are about to shut; this warning is supplemented by loudspeaker three seconds before they close. Safety interlocks have been provided to prevent a lift from being moved until both car and landing doors are closed. Each car is equipped with safety gear which would bring it to a standstill in the event of a breakage of a hoist rope or if the car exceeded a speed 20 per cent. in excess of normal at maximum load. Should a car stop in the lift shaft, an alarm bell and indicator warn the station staff and a ventilator is automatically switched on.

To provide the additional over-run required because of the greater speed of the cars, the floor of the machine room over the shaft had to be raised by 7 ft. 9 in. and the bottom of the shaft lowered by 2 ft. 6 in. Access to the top of each car for maintenance staff is by a screened walkway above the upper-landing doors. The screen contains doors which, being interlocked with the control system, cannot be opened unless the car is in the correct position; similarly, the car cannot be moved from that position while the screen doors are unlocked. A push button in the control box on top of the car cuts out all other controls during maintenance work.

The new lifts have been supplied and installed by Waygood-Otis, Ltd., Falmouth-road, London, S.E.1; the replacements have taken 20 months.

The table of this 216-in. turbine-gear hobbing machine is counterbalanced by hydraulic pressure which may be adjusted to give a constant bearing load. The machine incorporates eight motors and may, in an emergency, be driven by direct current.

TURBINE-GEAR HOBBING MACHINE

Separate Drives for Roughing and Finishing

A 216-in. turbine-gear hobbing machine, which incorporates in the table drive two independent dividing wormwheels, one of coarse pitch for initial roughing cuts and setting-up, and a fine-pitch wheel for finishing, has been built by David Brown Machine Tools, Limited, Sherborne-street, Manchester, 3. The fine-pitch, or master, wormwheel is split across a plane at right angles to its axis so that by rotating the halves with respect to one another, greater adjacent and cumulative accuracy of pitch may be obtained. The machine is to be installed in a temperature-controlled machine shop on the premises of the shipbuilding company, Ansaldo Soc. per Az., Genoa, Italy, and has been made in accordance with B.S. 1498 : 1948, Grade "A."

Approximately 105 tons in weight, this machine, which is shown in the illustration above, is designed to cut the teeth of turbine wheels from 90 in. to 216 in. in diameter and with a maximum diametral pitch of 1½. It has a vertical hob-slide traverse of 106 in. and traversing speeds ranging from 0·01 in. to 0·106 in. per revolution of the table.

The centre distance from the hob in its highest position to the table is 115 in., and the table, which is 174 in. in diameter, has a 42-in. bore. Hob speeds from 15 r.p.m. to 60 r.p.m. may be selected and the in-feed is 0·036 in. for each revolution of the table.

It is impossible to engage both wheels simultaneously since electric interlocks prevent the starting of the independent table motor when the fine-pitch master wormwheel is engaged. The change gears for the feed, and also for spiralling indexing and prime mechanisms are situated together in the main gearbox at one side of the machine.

The master wormwheel has 950 fine-pitch teeth of special proportions and design to give the greatest possible number of teeth in continuous engagement with the worm. One half of the split wormwheel is rotated relative to the other between semi-finishing cuts and thus, by a process of measuring and further cutting, greater adjacent and accumulative accuracy of pitch is achieved.

Vertical travel of the hob, shown in detail in the picture below, is effected by a large lead screw, mounted centrally between the guideways, which are of comparatively narrow section to give increased precision.

The screw is adjusted by means of two nuts, one of which is fixed and the other loose for setting purposes. A large seating on the hob saddle locates the hob slide, and slide and base can be swivelled under power through 180 deg. so that either right or left-hand helical teeth can be cut.

The hob-driving spindle, on which is mounted a flywheel, is located in the final drive by multiple splines. A conical bearing, shown in the close-up view at the right-hand end of the spindle, designed to facilitate the accurate alignment of spindle and hob-shaft, is capable of axial adjustment, by which any errors due to excessive clearance can be quickly rectified.

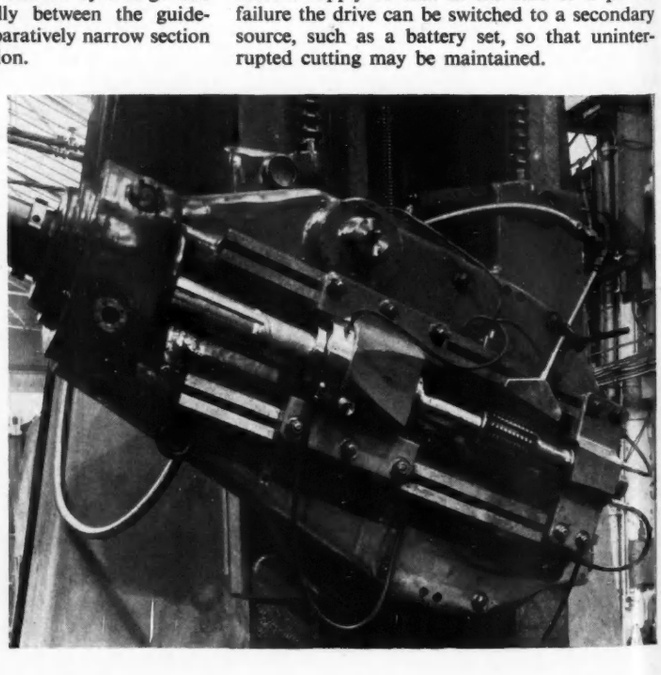
Movement of the upright pillar along the bed of the machine is normally power driven but it can also be performed by hand with the aid of a screw and reduction gearing. Recesses are provided in the pillar guideways into which oil can be pumped under pressure to relieve the load, thereby permitting free and precise traversing.

HYDRAULIC SUPPORT FOR TABLE

To accommodate more easily the wide range of gears within its cutting capacity, the 216-in. machine is designed so that part of the load on the table is counterbalanced by hydraulic pressure. The pressure can be adjusted to suit each gear and enables a constant bearing pressure to be maintained irrespective of the gear weight.

Oil is supplied to the table unit by two 1-h.p. gear-pump motors mounted in tandem. One pump supplies oil to the table-load relief and the other feeds lubricating oil to the two sets of dividing gears and the main gearbox. The gears and bearings in the hob slide are automatically and continuously lubricated. A third gear pump circulates cutting oil. Eight motors provide power for the main drive, the hob-slide traverse, the traverse of the pillar, the rapid traverse of the table and the lubricating and coolant pumps, both of which have reserve motors. These two drives are duplicated since their failure is most likely to cause damage ; the standby motors are automatically brought into action if the primary motors cease to function.

As an additional precaution the variable-speed main motor, the output of which ranges from 10 h.p. to 20 h.p., and the 1-h.p. lubricant and coolant pump motors, are arranged for direct-current supply so that in the case of a power failure the drive can be switched to a secondary source, such as a battery set, so that uninterrupted cutting may be maintained.



The drive to the hob is fitted with a flywheel.

Labour Notes

WAGE INCREASE PROPOSALS ACCEPTED

Offers of increases in the wages of engineering and shipbuilding employees, made by the Engineering and Allied Employers' National Federation and the Shipbuilding Employers' Federation on March 31 and April 1, respectively, were accepted by representatives of the 39 unions affiliated to the Confederation of Shipbuilding and Engineering Unions at a meeting at York on April 8.

When the meeting opened, the executive council of the Confederation introduced a motion recommending acceptance of the employers' offers and this was eventually agreed to by 102 votes to 39. The increases will have the effect of raising the consolidated time rates of adult skilled male operatives by 8*s.* 6*d.* a week, those of semi-skilled employees by 7*s.* 6*d.* a week, and those of unskilled men by 6*s.* 6*d.* a week. Proportionate increases are expected to be granted to women and juvenile employees.

The higher rates of wages will be paid as from April 5 and it is expected that, in all, some 3,000,000 workpeople, including over 200,000 shipyard employees, will benefit by them. It is estimated that these increases will add between 60 and 70 million pounds a year to the wage bill of the two industries.

In April last year, when the claims were first presented, the Confederation asked for an all-round increase of 15 per cent. The advances now granted to the unions are in the region of 6 per cent.

DISSATISFACTION OF UNSKILLED EMPLOYEES

The only disapproving note in the settlement of the claims appears to have come from the unions which represent mainly unskilled workpeople. An amendment to the executive council's motion of acceptance was moved by Mr. J. Matthews, national industrial officer, National Union of General and Municipal Workers, who proposed that the executive council should approach the engineering and shipbuilding employers' Federations again, with a view to obtaining some further improvement in the proposed new rates for the unskilled grades.

Mr. Matthews suggested that the Confederation was not being consistent in accepting the employers' offers on the basis on which they were made. The amendment was seconded by Mr. H. Nicholas, of the Transport and General Workers' Union, who pointed out that the employers' proposals provided for an increase of 6·25 per cent. for skilled men, but only 5·5 per cent. for unskilled employees. He reminded the delegates that the Confederation's original claims were for an equivalent percentage for all grades and that the courts of inquiry set up to investigate the claims had made no suggestion that the percentage of increase for skilled and unskilled operatives should differ.

The amendment was defeated by a large majority and the executive council's motion for acceptance carried, as stated above.

RAILWAY SHOPMEN'S WAGE INCREASE APPROVED

The same meeting of executive officials of the Confederation's affiliated unions on April 8 also agreed to accept the proposals of the British Transport Commission for wage increases for railway shopmen employed on British Railways. These increases will improve the time rates of adult men by 8*s.* a week for skilled craftsmen, 7*s.* 6*d.* a week for semi-skilled operatives and 7*s.* a week for the unskilled grades. The agreement will provide proportionate increases for women and juveniles.

These increases were negotiated jointly by the Confederation and the National Union of Railwaymen, to which the men belong. Some 116,000 railway shopmen will benefit from the increases, which are expected to cost the Commission at least two-and-a-half million pounds a year.

As in the case of the shipbuilding and engineering employees generally, the unions had originally looked for increases of 15 per cent. The advances granted are flat-rate increases and will amount to approximately 6 per cent. of existing rates. The question of the increases dating back to December, 1953, instead of to January last, which at one time appeared to be an obstacle to the settlement of the claim, seems not to have been raised at the meeting on April 8.

THREATS OF RAILWAY STRIKE ACTION WITHDRAWN

Following the threats of the Associated Society of Locomotive Engineers and Firemen to withdraw the labour of its members, mostly engine-drivers and firemen, from the service of British Railways, as from April 24, in connection with the dispute over a revised wage structure, a meeting between representatives of British Transport Commission and the three principal railway unions took place in London on April 7. Sir Brian Robertson, the chairman of the Commission, laid before the unions the Commission's proposals for a new railway structure for the railway service.

It was the Commission's failure to produce proposals of its own at an earlier date which led to the decision of the A.S.L.E.F. to call out its 70,000 members on strike on April 24, unless the Commission placed its suggestions before the unions prior to that date.

Details of the Commission's proposals have not been made known but the representatives of the three unions undertook to consult their executive councils and it was agreed that there should be a further joint meeting between the Commission and the unions prior to the Easter holidays.

A statement issued by Mr. J. G. Baty, the general secretary of the A.S.L.E.F., after a meeting of his union's executive council on April 8, announced that the council had decided to rescind its decision to withdraw the labour of the union's members on April 24. Mr. Baty also acknowledged that the Commission's proposals would be subject to further negotiation and stated that, in view of the responsible nature of the duties performed by footplate men, the council intended to pursue the proposals which had already been made by the union. These would increase the wages of engine-drivers with six years' seniority from £8 16*s.* 6*d.* a week, as at present, to £10 5*s.* a week.

At the same time, Mr. Baty declared, the council would not tolerate any undue delay in the ensuing negotiations.

INDUSTRIAL TEACHERS NEEDED BY YOUNG EMPLOYEES

Reports presented to a conference at Manchester College, Oxford, on the assimilation of young employees into industry, urged that greater assistance should be given to juveniles in making the difficult transition from school to office or factory, and during their early years in industry.

It was suggested that there was a great need in industry for persons who could create relationships with young people similar to those which existed between teachers and pupils at school. Unless such opportunities were provided, school-leavers might form other, and less desirable, relationships elsewhere.

An idea put forward at the conference was that introductory courses of study should be organised in all industries for the benefit of new entrants, and that these courses should be open to all juveniles, whether they were apprentices or not. It was considered that subjects to be dealt with on such courses might well include the history and organisation of the industry which the new-comer had entered, the part it was called upon to play in the country's economy, significance of individual employees, and the importance of their contributions to the wellbeing of the industry and the nation.

Persons chosen for this work should be specially selected and trained. It should be part of their duties to smooth the paths of new-comers during their early careers in industry, and to be ready with informal advice on difficulties.

The conference, which was entitled "The Young Worker: Education for Human Relations," was organised by the Department of Education of the University of Oxford, and was held during the seven days ended April 9.

COAL PRODUCTION IN 1954

Statistics issued by the Ministry of Fuel and Power on April 8, show that, during the first three months of this year, 57,175,000 tons of deep-mined and 2,686,500 tons of opencast coal were produced at mines in Great Britain, making a total for the period of 59,861,500 tons. During the corresponding period of 1953, some 59,356,500 tons of coal were produced, of which 56,524,800 tons were deep-mined and 2,831,700 tons were opencast.

Coal imports into Britain amounted to 185,000 tons during the first quarter of this year compared with no such imports during the corresponding period last year. Wage-earners on colliery books have declined in number in 1954. During the twelve weeks ended March 27 last, the average weekly total of coal-mining employees in Britain was 708,700, of whom 291,700 were engaged at the coalface. During the twelve weeks ended March 28, 1953, there was an average weekly total of 716,700 miners on colliery books, of whom 292,400 were engaged at the coal-face.

Shifts worked per wage-earner increased from an average of 4·94 a week in 1953 to 4·98 a week in 1954.

EMPLOYMENT IN BRITAIN

The working population in Great Britain declined by 11,000 during January and February last, to a total of 23,463,000 persons at the end of February, of whom 15,930,000 were men and boys, and 7,533,000 were women and girls. These figures are almost identical with those at the end of December, 1953, when there were 15,920,000 men and boys, and 7,554,000 women and girls, at work in Great Britain, making a total of 23,474,000 persons.

The strength of the Armed Forces declined from 850,000 at the end of December to 844,000 at the end of February. About 23,000 of the total at the end of February were women.

According to statistics issued by the Ministry of Labour and National Service on April 8, there were 3,993,000 persons employed in the basic industries, 8,959,000 persons at work in the manufacturing industries, and a further 9,321,000 persons engaged in other occupations such as building, the distributive trades, professional services, and public administration, at the end of February. There were thus 22,273,000 persons in civil employment at that date.

Persons registered as unemployed on March 15 last numbered 342,900, of whom 16,300 were only temporarily out of work.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

SOUTHAMPTON
"Joints for Power Cables," by B. A. Maxted. Polygon Hotel, Southampton. Wed., April 21, 8.15 p.m.

British Institution of Radio Engineers

LONDON
"Crystal Valves in Radio and Electronics," by B. R. A. Bettridge. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., April 21, 6.30 p.m.
WOLVERHAMPTON
"Radio Telephone Equipment," by T. C. Howell. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Tues., April 27, 7.15 p.m.

Chemical Society

EDINBURGH
"The Story of the *iso*Quinoline Alkaloids," by Dr. R. H. F. Manske. Centenary Lecture. University Biochemistry Department, Teviot-place, Edinburgh. Tues., April 27, 5.30 p.m.
LIVERPOOL
"The Story of the *iso*Quinoline Alkaloids," by Dr. R. H. F. Manske. Centenary Lecture. Joint meeting with other societies. Chemistry Lecture Theatre, The University, Liverpool. Fri., April 23, 5 p.m.
NEWCASTLE-UPON-TYNE
"The Story of the *iso*Quinoline Alkaloids," by Dr. R. H. F. Manske. Centenary Lecture. Newcastle and Durham Branch. King's College, Newcastle-upon-Tyne. Fri., April 30, 5.30 p.m.
ST. ANDREWS
"The Story of the *iso*Quinoline Alkaloids," by Dr. R. H. F. Manske. Centenary Lecture. St. Andrews and Dundee Branch. United College, St. Andrews. Thurs., April 29, 5.15 p.m.
SWANSEA
"Some Reactions of Free Radicals," by Dr. W. A. Noyes. South Wales Branch. University College, Swansea. Mon., April 26, 6 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Welding," by F. A. Thomas. Imperial Hotel, Birmingham. Fri., April 30, 7.30 p.m.
BRISTOL
Discussion on "The Gas-Turbine Locomotive." Western Branch. Grand Hotel, Bristol. Wed., April 21, 7.15 p.m.
GLASGOW
"Hospital Heating: Modern Methods," by W. Russell. Scottish Building Centre, 425-427 Sauchiehall-street, Glasgow. Wed., April 21, 7 p.m.
LEEDS
"Fluid Drive in Industrial Application," by E. C. Farrer. West and East Yorkshire Branch. The University, Leeds. Mon., April 26, 7.30 p.m.
LIVERPOOL
Chairman's Address. Merseyside and North Wales Branch. Radiant House, Bold-street, Liverpool. Mon., April 26, 7.15 p.m.
ROCHESTER
Discussion on "Self-Oiling Bearings." Kent Branch. Bull Hotel, Rochester. Wed., April 21, 7 p.m.
SHEFFIELD
Various short papers by members. Sheffield Branch. Grand Hotel, Sheffield. Thurs., April 29, 7.30 p.m.

Institute of British Foundrymen

LONDON
Annual General Meeting. Film on "Dust Extraction," presented by W. H. White and W. B. Lawrie. Waldorf Hotel, Aldwych, W.C.2. Wed., April 28, 7 p.m.
BIRMINGHAM
Annual General Meeting. "Some Running and Feeding Methods Used for Grey-Iron Castings," by P. A. Russell. James Watt Memorial Institute, Birmingham. Wed., April 28, 7.15 p.m.
BRADFORD
Annual General Meeting. West Riding of Yorkshire Branch. Technical College, Bradford. Sat., April 24, 6.30 p.m.
BRISTOL
Annual General Meeting. Bristol and West of England Branch. Grand Hotel, Bristol. Sat., April 24, 3 p.m.
LINCOLN
Short Paper Competition. Lincolnshire Branch. Lincoln Technical College, Lincoln. Thurs., April 22, 7.15 p.m.
MANCHESTER
Annual General Meeting, Short Paper Competition, and Foundry Brains Trust. Lancashire Branch. Engineers' Club, Albert-square, Manchester. Sat., April 24, 3 p.m.
SOUTHAMPTON
"Methods Employed in the Production of Heavy Iron Castings," by J. Richardson and C. F. Lawson. Southampton Technical College, St. Mary-street, Southampton. Thurs., April 22, 7 p.m.

Institute of Fuel

LONDON
"The New Education Scheme of the Institute of Fuel," by Dr. D. T. A. Townend. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., April 29, 5.30 p.m.
MANCHESTER
Annual General Meeting. "Energy in the Future," by Dr. J. Bronowski. North-Western Section. Engineers' Club, Manchester. Wed., April 28, 2.30 p.m. (Members' Luncheon, 1 p.m.)
NEWCASTLE-UPON-TYNE
Annual General Meeting. North-Eastern Section. King's College, Newcastle-upon-Tyne. Mon., April 26, 6.30 p.m.
NOTTINGHAM
"The Future of Our Power Supplies," by Professor F. E. Simon. East Midland Section. East Midlands Gas Board's Showrooms, Parliament-street, Nottingham. Thurs., April 22, 6.15 p.m.

Institute of Marine Engineers

LONDON
"New Metals in Engineering," by Dr. L. B. Pfeil. Tues., April 27, 5.30 p.m.
WEST HARTLEPOOL
"Water Treatment," by J. T. Aynsley. North-East Coast Section. Technical College, West Hartlepool. Thurs., April 22, 7 p.m.

Institute of Refrigeration

LONDON
"Valve Behaviour and the Performance of Small Compressors," by J. F. T. Maclaren. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Tues., April 27, 5.30 p.m.

Institute of Road Transport Engineers

LONDON
"Some Factors Affecting Fuel Consumption," by W. T. Skinner. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., April 22, 6.30 p.m.
GLASGOW
Annual General Meeting. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., April 26, 7.30 p.m.
WIGAN
Annual General Meeting. North-West Centre. Victoria Hotel, Wigan. Wed., April 21, 7.30 p.m.

Institution of Chemical Engineers

LONDON
Symposium on "Fuel and Power in the Chemical Industry." Graduates' and Students' Section. Battersea Polytechnic, S.W.11. Fri., April 23, 9.30 a.m.
Annual General Meeting. Graduates' and Students' Section. University College, Gower-street, W.C.1. Sat., April 24, 10 a.m.

Institution of Civil Engineers

LONDON
James Forrest Lecture on "The Geological Survey of Great Britain," by Dr. W. J. Pugh. Tuesday, April 27, 5.30 p.m.
SHEFFIELD
Annual General Meeting. "Land Drainage in England and Wales," by E. A. G. Johnson. Yorkshire Association. Royal Victoria Station Hotel, Sheffield. Fri., April 30, 7 p.m.

Institution of Electrical Engineers

LONDON
"Safety in the Use of Portable and Transportable Electrical Equipment in Industry," by J. Bunting. Utilization Section. Thurs., April 22, 5.30 p.m.
Discussion on "A Method for the Plotting of Magnetic Fields Due to Currents," opened by Dr. F. T. Chapman and D. G. Sandeman. Education Discussion Circle. Fri., April 23, 5.30 p.m.
"The Experimental Synthesis of Speech," by W. Lawrence. Radio Section. Mon., April 26, 5.30 p.m.
"Auto-Self-Excited Transductors and Push-Pull Circuit Theory," by A. G. Milnes and T. S. Law; and "Composite Cores for Instrument Transductors," by Dr. E. H. Frost-Smith and A. E. De Barr. Measurements Section. Tues., April 27, 5.30 p.m.
"Aluminium-Sheathed Cables," by P. M. Hollingsworth and P. A. Raine. Supply Section. Wed., April 28, 5.30 p.m. Kelvin Lecture on "The Physics of the Ionosphere," by J. A. Ratcliffe. Thurs., April 29, 5.30 p.m.

Institution of Locomotive Engineers

LONDON
"Locomotive Diagramming and Utilisation," by L. C. Welborn. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., April 21, 5.30 p.m.

Institution of Mechanical Engineers

LONDON
James Clayton Paper on "A New Frontier: Air-Pollution Control," by Frederick S. Mallette. Fri., April 23, 4.15 p.m. Discussion on "The Mathematical Content of Engineering Courses." Education Group Meeting. Wed., April 28, 6.45 p.m.
"Nodular Cast Iron: Its Present Position and Future Prospects as an Engineering Material, with Special Reference to Its Suitability for Crankshafts," by S. B. Bailey. Automobile Division and Applied Mechanics Group. Fri., April 30, 5.30 p.m.
BRISTOL
"Brakes for High-Speed Automobiles," by J. A. Channer. Western A.D. Centre. Car Division Offices, Bristol Aeroplane Co., Ltd., Filton, Bristol. Thurs., April 29, 6.45 p.m.
GLASGOW
James Clayton Paper on "A New Frontier: Air-Pollution Control," by Frederick S. Mallette. Scottish Branch. Royal Technical College, George-street, Glasgow. Thurs., April 29, 7.30 p.m.
LEEDS
"Operating Experiences with a 759-kW Gas Turbine," by G. B. R. Feilden. North-Eastern A.D. Centre. Chemistry Lecture Theatre, The University, Leeds. Wed., April 21, 7.30 p.m.
LINCOLN
"Contemporary Methods of Watch Production," by R. A. Feil and P. Indermuhle. East Midlands Branch. Technical College, Lincoln. Wed., April 28, 7.30 p.m.
MANCHESTER
James Clayton Paper on "A New Frontier: Air-Pollution Control," by Frederick S. Mallette. North-Western Branch. College of Technology, Sackville-street, Manchester. Mon., April 26, 6.45 p.m.
PORTSMOUTH
Repetition of the Address by the Chairman of the Automobile Division: "Combustion in Compression-Ignition Oil Engines," by Professor S. J. Davies. Southern Branch. Anglesey Road Extension, Portsmouth Municipal College, Portsmouth. Thurs., April 29, 7 p.m.

Institution of Mining and Metallurgy

LONDON
"The Production of Asbestos in South Africa," by W. E. Sinclair; and "Geochemical Prospecting at Mount Isa, Queensland," by A. H. Debnam. Geological Society's Apartments, Burlington House, Piccadilly, W.1. Thurs., April 22, 5 p.m.

Institution of Production Engineers

LONDON
"Machine Tool Replacement," by T. P. N. Burness. London Graduate Section. Tues., April 20, 7.15 p.m.
BIRMINGHAM
"The Training of the Young Engineer," by J. Wilson. James Watt Memorial Institute, Birmingham. Wed. April 21, 7 p.m.
LUTON
Film Evening. Town Hall, Luton. Tues., April 27, 7.15 p.m.
MANCHESTER
"Modern Gear Production," by H. J. Watson. College of Technology, Sackville-street, Manchester. Mon., April 26, 7.15 p.m.
NEWCASTLE-UPON-TYNE
Open Meeting. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., April 19, 7 p.m.
SHEFFIELD
"Some Aspects of the Study of Working Methods," by A. B. Armstrong. Sheffield Graduate Section. Sheffield College of Commerce and Technology, Pond-street, Sheffield. Mon., April 26, 7 p.m.
SHREWSBURY
"How the Production Engineer Can be Helped by Research," by P. Spear. Shrewsbury Section. Walker Technical College, Oakengates, Shropshire. Wed., April 28, 7.30 p.m.
WOLVERHAMPTON
"The Application of Metal Arc Welding," by E. Flintham. Wolverhampton Graduate Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Thurs., April 22, 7.30 p.m.

Institution of the Rubber Industry

BIRMINGHAM
Annual General Meeting. Midland Section. James Watt Memorial Institute, Birmingham. Thurs., April 29, 6.45 p.m.
LEICESTER
Annual General Meeting and Film Evening. Bell Hotel, Leicester. Fri., April 23, 7.30 p.m.
LIVERPOOL
Annual General Meeting. "Advertising," by T. G. Hartshorne. Merseyside Section. Electricity Supply Showrooms, Whitechapel, Liverpool. Mon., April 26, 7 p.m.
MANCHESTER
Annual General Meeting. Engineers' Club, Manchester. Mon., April 26, 6.15 p.m.

Institution of Structural Engineers

LONDON
"Fatigue of Welded Structures," by Dr.-Ing. R. Weck. Thurs., April 22, 6 p.m.
BIRMINGHAM
Annual General Meeting. "Some Factory Building Maintenance Problems," by W. T. Dudley. Midland Counties Branch. James Watt Memorial Institute, Birmingham. Fri., April 30, 6 p.m.
MANCHESTER
Annual General Meeting and Film Evening. Lancashire and Cheshire Branch. College of Technology, Manchester. Wed., April 28, 6.30 p.m.

Junior Institution of Engineers

LONDON
"Engineering Maintenance in a Paper Mill," by N. A. Holmes. Townsend House, Greycoat-place, S.W.1. Fri., April 23, 7 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Some Practical Effects of Tip Clearance in Turbine Blading," by J. L. Jefferson. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Fri., April 23, 6.15 p.m.

Royal Meteorological Society

LONDON
Annual General Meeting. Presidential Address on "The Development of Meteorology as an Exact Science," by Dr. O. G. Sutton. Wed., April 28, 5 p.m.

Royal Microscopical Society

LONDON
"A New Lamp for Visual Microscopy" and "A Re-designed Rousslet Compressor," by Dr. J. R. Baker (with demonstrations); and "A Simplified Micro-Manipulator," by Dr. R. J. Goldacre (with demonstration). Wed., April 21, 5.30 p.m.

The Royal Society

LONDON
Discussion on "The First and Second Viscosities of Fluids," to be opened by Professor L. Rosenhead. Thurs., April 29, 2.15 p.m.

Royal Society of Arts

LONDON
"Official Printing and Typographical Design," by Harry G. Carter. Wed., April 28, 2.30 p.m.

Royal Statistical Society

LONDON
"The Outlines of the Roads Goods-Transport Industry," by K. F. Glover and D. N. Miller. London School of Hygiene and Tropical Medicine, W.C.1. Wed., April 28, 5.15 p.m.
NEWCASTLE-UPON-TYNE
Annual General Meeting. 6.45 p.m. "Sensory Tests in Industrial Research," by K. R. Williams, 7.15 p.m. Armstrong Buildings, King's College, Newcastle-upon-Tyne. North-Eastern Industrial Applications Group. Wed., April 21.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 54 Station-road, New Barnet, Hertfordshire. (BARnet 9141.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Refrigeration, Dalmeny House, Monument-street, London, E.C.3. (MINcing Lane, 6851.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1, Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. (MONarch 2096.)
Institution of Production Engineers, 36 Portman-square, London, W.1. (WELbeck 6813.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, 39 Victoria-street, London, S.W.1. (ABBey 6968.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1. (Newcastle 20289.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Microscopical Society, Tavistock House South, Tavistock-square, London, W.C.1. (EUSton 2048.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)